ACCREDITED with 'A' Grade (CGPA 3.22 out of 4.0) by NAAC

ISO 9001:2015 Certified



MASTER OF TECHNOLOGY (M. Tech.)

ORDINANCE, REGULATIONS, SCHEME & SYLLABUS

दिल्ली प्रौद्योगिकी विश्वविद्यालय

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

(Estd. By Govt. of NCT of Delhi vide Act 6 of 2009)



Revised M.Tech Scheme with effect from the academic session 2019-20 for Full Time / Part Time Programme

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Initially Established with the name "Delhi Polytechnic"
In the year 1941 at Kashmere Gate Campus

In the year 1965 renamed as
Delhi College of Engineering
Reconstituted
Delhi Technological University in the year 2009

Vide Govt. of NCT of Delhi Act 6 of 2009

-A non-affiliating
Technological University

"Committed to
Foster Engineering Excellence
And
Scientism together"

About Delhi Technological University

Delhi Technological University (DTU) is a non affiliating, teaching and research University at Delhi to achieve excellence in science, engineering, technology, management and allied areas and matters connected therewith or incidental thereto. The University enables students to face the wide-ranging changes taking place in the fields of science, technology, environment and management. This includes innovation, design, development, construction, production, managerial and entrepreneurial activities. The University lays great emphasis on assisting students in the development of national character, self-confidence, leadership and fostering an ecosystem for creativity and imagination.

Delhi Technological University was upgraded from Delhi College of Engineering by the Government of NCT of Delhi in 2009. The University has an illustrious history spanning over 78 years. This university was initially established with the name of Delhi Polytechnic in the year 1941 to cater to the needs of Indian industries for trained technical manpower with practical experience and sound theoretical knowledge. From academic year 2017-18 the East campus of DTU is also functional which offers courses like Bachelor of Business Administration (BBA), Bachelor of Arts, (Honours) in Economics, and Master of Business Administration (MBA).

This premier institution is globally well-known for its outstanding education, research, and innovations. The University currently offers various inter-disciplinary and industry relevant-programs in science, technology, management, and allied areas at both the undergraduate and postgraduate level. The University has established a strong academia-industry interface and has collaborations with reputed research organizations, industries, and premier institutions.

The university has taken several initiatives in recent past to engage the students and faculty in research and innovation like provision of funding for students' innovative projects, financial assistance to students for attending internship overseas, introduction of three different tracks in elective courses in B.Tech. Curriculum namely (a) research (b) product development and (c) entrepreneurship, research project grant to faculty members etc.

Vision & Mission of the University

Vision:

"To be a world class university through education, innovation, and research for the service of humanity"

Mission:

1. To establish centres of excellence in emerging areas of science, engineering, technology, management, and allied areas.
2. To foster an ecosystem for incubation, product development, transfer of technology, and entrepreneurship.
3. To create environment of collaboration, experimentation, imagination, and creativity.
4. To develop human potential with analytical abilities, ethics, and integrity.
5. To provide environment friendly, reasonable and sustainable solutions for local and global needs.

Core Values of the University

Integrity We do what we say through trust, transparency and honesty.

Compassion We foster civilized mindset for kindness, consideration and benevolence.

Commitment We dedicate ourselves completely to all our endeavours.

Creativity We nurture innovation, imagination and ideation.

Collaboration We promote team work through togetherness, harmony and acknowledgement.

Inclusion We embrace diversity with respect, acceptance and affirmation.

Quality Policy

The university is committed to achieving global standards of excellence in the field of Science, Technology, Management and allied areas by disseminating knowledge through cutting-edge research, education and innovation. We adopt best practices to maintain high standards in the core and allied functions through continuous evaluation and improvement of our processes.

Programs Offered

The university offers 14 undergraduate engineering programs, 22 post graduate engineering programs and 3 MBA programs. Additionally, an M.Tech. program in Geoinformatics, two MBA programs in (i) Family Business & Entrepreneurship (ii) Entrepreneurship, Innovation and Venture Development and M.Sc. programs in Biotechnology, Mathematics and Physics are being started from academic session 2019-20. Besides this the university offers other 3 other bachelor programs namely B.Des., BBA and BA (Honours) Economics. The engineering programs include disciplines of mechanical engineering, civil engineering, electrical engineering, electronics and communication engineering, computer engineering, environmental engineering, software engineering, mathematics and computing, automobile engineering, polymer science and chemical technology.

The post graduate engineering programs cover VLSI design and embedded systems, software engineering, computer engineering, microwave and optical communication, polymer technology, power systems, signal processing and digital design, geotechnical engineering, structural engineering, nanoscience technology, and bioinformatics.

The UG and PG programs of DTU offer most modern curricula, based on the Choice Based Credit System (CBCS), having rich mix of courses from science, engineering, management, social sciences, humanities, fine arts, liberal arts, classical music, sports, etc. The course curricula have been developed with a view to integrate advancements in science and engineering, while also incorporating industry relevant technologies. To provide further flexibility there is provision for credit transfer and earning credits through massive online courses (MOOCs) from different platforms such as NPTEL, SWAYAM, Coursera and Edx etc. The Curriculum is regularly updated keeping in view the new technologies and changes in industries and society.

Ranking and Rewards

The university has been consistently ranked among best 10 engineering institutions as per the various Independent Surveys on Best Engineering Institutions of the country. The university has got 2nd position as per Times Engineering Ranking 2019.The University has been ranked 7th by India Today's best government engineering colleges ranking 2019. The 2019 NIRF rankings placed DTU at the 34th position among the engineering institutions and at 47th in the universities.

The university has been granted with the Technical Education Quality Improvement Program (TEQIP)

project. The TEQIP-III Project started in DTU in July 2017.The project provides funds to faculty and students to organize and attend various faculty development programs, seminars, and conferences.

Based on the idea to recognize the achievements of faculty and students at DTU, the Research Excellence Awards were constituted in 2017. The purpose of these awards is to encourage and promote research culture in all the disciplines of the university and to celebrate the individual's excellence in research. The university offers three categories of awards annually, namely: *Outstanding Research Awards, Premier Research Awards,* and *Commendable Research Awards*. The awards are open to all the researchers of DTU. The university has also constituted Awards for Teaching Excellence for the faculty members of DTU.

Campus and Infrastructure

DTU has 164 acres of a lush green, tech-savvy main campus, with 150,000 sq. mtr. of built up area, 14 academic departments, research centres, and residences for students, faculty, and staff. The university has around 10,000 students in its undergraduate, postgraduate, and PhD programmes. The library is a central place for academic and research activities. It has a well-equipped conference hall, reading rooms, and a rich collection of relevant books and journals. DTU has an EDUSAT Studio utilized for recording of lectures, events, and talks. Also, DTU has a wireless network connecting the computer centre, the academic wings, the administrative block, and the hostels on a common platform. The students have access to high speed internet services.

The university has established the DTU Innovation and Incubation Foundation, pursuant to sub-section (2) of section 7 of the Companies Act, 2013 and rule 8 of the Companies (Incorporation) Rules, 2014. Currently, 14 teams are working in the Centre. The aim of the DTU Innovation and Incubation Foundation is to create a culture of entrepreneurship, startups, and Intellectual Property Creation that leads to value creation, jobs, and employment, and does social and economic good by creating a robust ecosystem. The centre offers incubation infrastructure, including space, computing resources, connectivity, common tools; and environment for co-working, collaboration, and innovation.

The university has also established centers like Center of Outreach & Extension Activities and Center of Human Resource Development (HRDC). The Center of Outreach & Extension Activities aims to organize a variety of activities for promoting public awareness. The Outreach and Extension Center annually organizes an awareness program on engineering for class X/XI/XII students of private and government schools. The HRDC center aims to upgrade and enhance the skills and knowledge of faculty at DTU. The center recently organized a faculty development program "Game Changer" for the newly recruited assistant professors in the university.

The university has a well-equipped centralized computer centre to cater to the needs of highly creative intellectual students and faculty community. The centre possesses HP and Dell high performance servers, along with Intel core i5 computer systems in its labs. The centre is fully networked through high-end intelligent Aruba/Avaya switch/controllers and possesses round-the-clock two leased lines of 10 Gbps (NKN) & 200Mbps (Airtel) for WiFi and LAN connectivity in the entire campus.

The students of DTU are provided with excellent facilities for indoor and outdoor games. DTU has 4x400 mtr. racing track, fields for football, hockey, cricket, courts for volleyball, basketball, tennis, badminton, along with facilities for indoor games. A well-equipped gymnasium is also available in the campus in addition to gym facilities in each hostel. The university has appointed coaches in almost all the games to coach the students and prepare university teams. Students are encouraged to participate in various sporting events and tournaments, held in and around NCR of Delhi. From academic year 2018-19, as per the revised curriculum, the university offers foundation electives to

the students of first year and second year and in this sports have big share of electives. In 2018-19, approximately 475 students opted for sports in first and 500 in second semester. The number is expected to double this year.

The University has 9 Boys and 6 Girls hostels to accommodate 1289 male and 334 female students. Every hostel has its own common room and gymnasium. The hostels are connected to the campus via the campus-wide WiFi network, enabling the residents to browse the Internet and access online library resources for their academic and research-related tasks. DTU has a full-fledged health centre where services of five medical practitioners and round the clock nursing facilities are available.

Two new academic blocks and three hostel blocks are under construction. It will provide the academic infrastructure for 3000 students. Further, the increase in hostel capacity will accommodate an additional 660 girls and 330 boys.

A multipurpose hall named Raj Soin Hall is under construction which will provide facility for organizing various programs for 3000 people. It can also be used for indoor sports. It will have food court and other facilities for the students. For this alumnus of the university Sh. Raj Soin has made a major contribution of Rs. Five Crores.

Events and Festivals

The university annually organizes cultural, literary, sports and technical festivals. These festivals not just provide an opportunity to the students to connect with the professional world, but also display their creative and technical skills in several interesting events and activities organized during the fests. The Engifest is annual cultural extravaganza of the university and offers a good mix of literary, cultural, and entertainment events. Further, there are a series of professional societies including IEEE, IETE, CSI, SSE and others. The Invictus is annual technical festival of the university where all technical societies of the university host various technical activities and competition. Some of major events include Troika, the festival by IEEE-DTU students chapter; Radix, a popular event on robotics where digitally-operated and mechanically-controlled robots participate in contests. In Junkyard, participants are required to create something interesting out of scrap. Brainwave is a hardware conceptualization contest aiming to showcase the latest among hardware designs, their synthesis and enhancement. Envision is a software development competition that sees participants coming up with path-breaking concepts. Innova is the jointly conducted techno-management fest of the Department of Mechanical and Production Engineering and the Department of Civil and Environmental Engineering. The Clay Play event in Innova is a design challenge where participants sketch their dream car and make a clay-model of it, which is adjudged on the basis of its aesthetic appeal and aerodynamic features. Ventura is another event where teams present their business plans to a panel of judges. The sports festival ARENA is organized annually. The festival witnesses large participation of boys and girls in various sports which include atheletics, cricket, tennis, basketball, volleyball, badminton, table tennis, carrom, chess etc.

University regularly organizes conferences, faculty development programs and workshops for learning through networking and academic growth of faculty and students. In academic session 2018-19 a total of 4 international conferences were organized one each by the Applied Mathematics, Electronics and Communication Engineering, Electrical Engineering and Mechanical Engineering departments.

The university also organizes **GIAN Courses** by inviting internationally-renowned faculty to deliver short-term courses with an aim to boost higher education in the campus. The lectures have been delivered by International faculty including Prof. Subhash C. Sarin, Virginia Tech, USA; Dr. Sanjay Kumar Shukla, Edith Cowan University, Australia; Prof. Saifur Rahman, Virginia Tech, USA; Dr.

Mohamad Sawan, Polytechnique Montreal, Canada; Prof. Elias Strangas, College of Engineering, Michigan State University, USA; Prof. Miguel Angel Sotelo, University of Alcala, Spain, and many others.

Placements

The university students are placed in reputed companies offering a promising and high profile career. Some of the companies that have recruited students during the campus placements include Flipkart, Amazon, Microsoft, Google, Goldman Sachs, Texas Instruments, Synopsys, SanDisk, Nvidia, Indian Oil, Maruti, Yahoo, Oracle, Samsung, Deloitte, McKinsey, Adobe, and L&T. The highest annual salary package has gone up to Rs. 1.25 crore per annum. A major highlight of placements at DTU is that the leading companies not only make job offers to the final year students, but they also offer paid internships to third year students. This enhances the industry interface further, preparing them for the technological challenges of the industries and in turn assure better pre-placement jobs offers for the students.

Students who have graduated from DTU are studying in various prestigious national and international institutes such as IIMs, IITs, Carnegie Mellon University, Columbia University, Duke University, Purdue University, University of Texas and University of California.

In all the university has all the possible academic, cultural and social infrastructure and environment to develop industry relevant and socially sensitive human resource for India and Globe.

Distinguished Alumni

DTU has provided the nation, as well as the world at large, with some of the best and finest engineering and technology professionals. They have, with distinction, led great enterprises and corporate houses in India and abroad, bringing immense glory to their alma-mater, all the while enhancing the pride of the engineering profession by their distinguished services performed with utmost sincerity and commitment.

The long list of distinguished alumni of this great institution includes Vinod Dham, 1971 EC, The Designer of Pentium Chip; Raj Soin, 1969 Mech, Chairman, Soin International, Ohio, USA; K.L. Chugh, 1960 Mech, former CMD, ITC; Ajoy Choudhury, 1958 Architecture, Eminent Architect; Dr. Durga Das Agrawal, 1967 Mech, President and CEO, Piping Technology and Products, Houston, USA; Prof. Bhuvenesh Goswami, 1959 Textile, Distinguished Alumni Professor, University of Clemson, USA; Prof. Yogi Goswami, 1969 Mech, Distinguished Professor of Solar Energy Technologies, University of Florida, USA; Yogesh Sud, 1969 Mech, NASA Gold Medalist Scientist; Surya Kant, Vice President and Head TCS America USA; A.K. Puri, 1975 Mech, Former CMD, BHEL; A.K. Baweja, Former CMD, Hindustan Aeronautics Ltd.; Sanjeev Ahuja, Former Chairman, Orange SA; Ashwani Kumar, CMD, Bharat Electronics Ltd.; Anil Sardana, Managing Director, Tata Power Ltd.; A.K. Purwaha, CMD, Engineers India Ltd.; S.K. Vij, former Member Railway Board and President, Indian Building Congress; Karnail Singh, IPS; Arun Goyal, IAS, Minister of Commerce and Industry, Indian Embassy, Tokyo, Japan; Vijay Shekhar Sharma, Founder, PayTM; Group Captain (Late) R.S Bhola, Olympic Winner, Ajay Dixit, CEO Cairn Oil &Gas, Vedanta Ltd., Archana Bhardwaj Executive Director IOCL, P.R Sheshadri, CEO and MD, Karur Vysya Bank Limited, Jayant Khosla CEO and MD VLCC, Sanjay Brahmawar, CEO,Software AG, and many more.

Our Glorious Past

"76 years of Tradition of excellence in Engineering & Technology Education, Research and Innovations" Delhi College of Engineering, (initially established with the name – Delhi Polytechnic) came into existence in the year 1941 to cater the needs of Indian industries for trained technical

manpower with practical experience and sound theoretical knowledge. The institution started its functioning at the historic Kashmere Gate campus as a follow up of the Wood and Abott Committee of 1938. It comprised of a multi disciplinary and multi level institution offering wide ranging programs in engineering, technology, art and sculpture, architecture, pharmacy and commerce. The national diploma awarded by the institution was recognized as equivalent to degree level for the purpose of employment. In 1952, the college was affiliated with University of Delhi and started formal Degree level programs. The department of Architecture later became the School of Planning and Architecture, now a Deemed University and Institution of National importance. The department of Arts and Sculpture became College of Arts and the departments of Chemical Technology and Textile Technology were shifted out en-block to mark beginning of the IIT Delhi at its new campus at Hauz Khas. The department of commerce was later abolished and the faculty of management studies of the University of Delhi was established by Prof. A Das Gupta, of DCE. Delhi College of Engineering is thus the mother institution of a number of national projects including IITD, SPA, College of Arts and even the famous FMS.

Till 1962, the college was under the direct control of Ministry of Education, Government of India. In 1963, the administration of the college was handed over to Delhi Administration. Delhi College of Engineering was under the administrative control of Department of Training & Technical Education, Govt. of NCT of Delhi. For academic purpose, the college was affiliated to University of Delhi since 1952. From July 2009, the DCE has become Delhi Technological University vide Delhi Act 6 of 2009.

The erstwhile DCE has functioned from its historic Kashmere Gate Campus for almost 55 years and has shifted in 1996 to its lush green sprawling campus of 164 Acres at Bawana Road, adjoining Sector-17, Rohini, Delhi. Its shifting to new campus has added the dimension of research and caused innovations in plenty, which has received high national and international acclaim. As Delhi Technological University, it has the desired autonomy to excel and shape itself as a world class Technological University.

Delhi Technological University

Ordinance (1-B)

Ordinance for the Undergraduate and Post Graduate degree programs of Delhi Technological University

(For batches 2018-19 and onwards)

Preamble

Delhi Technological University (DTU) is a non affiliating, teaching and research University at Delhi to achieve excellence in science, engineering, technology, management and allied areas and matters connected therewith or incidental thereto. It enables students to face the wide-ranging changes taking place in the fields of technology, environment and management with confidence. This includes undertaking design, development, construction, production, managerial and entrepreneurial activities, and higher studies in their chosen or allied interdisciplinary fields of study. The University lays great emphasis on assisting students in the development of National character, self-confidence, leadership and entrepreneurial skills.

1. Short title and Commencement:

(i) This ordinance shall be called the Ordinance 1 (B) 2018 meant for the undergraduate and post graduate degree programs of Delhi Technological University for batches 2018-19 onwards.

(ii) This ordinance shall come into force with effect from the date of Board of management approval.

2. Definitions: (a) In this ordinance, unless the contents otherwise require-

i. **"AC" and "Council"** shall mean the Academic Council of the Delhi Technological University.

ii. **"BoM"** shall mean the Board of Management of the University.

iii. **BoS** shall mean Board of Studies of the Department/ School

iv. **"CGPA"** shall mean the Cumulative Grade Point Average.

v. **Department** shall means a department of studies of the university.

vi. **School** shall mean a school of studies of the university.

vii. **"SGPA"** shall mean the Semester Grade Point Average.

viii. **"Student"** shall mean a student registered for undergraduate or post graduate program.

ix. **"University"** shall mean the Delhi Technological University.

x. **"UTTC"** shall mean University Time Table Committee.

(b) Words and expressions used but not defined in this ordinance and defined in the Act and Statutes, shall have the same meaning as assigned to them in the Act or Statute.

Note :*'He', 'Him' and 'His' implies 'he/she', 'Him / Her' and 'his/her', respectively.*

3. **Ordinance:**

i. The University shall offer UG and PG programs as approved by the BoM on the recommendation of the AC either on its own or on the initiative of a Department/ School, and/or on the direction of the BoM.

ii. The minimum entry qualifications and the policy and procedure of admission to the programs shall be such as may be approved by the AC.

iii. A student of a program shall be required to earn a minimum number of credits through various curricular components like lectures/tutorials/laboratory/studio courses, seminar, industrial training, project etc. at the University or at such other institutions/ industry as may be specified in the Regulations.

iv. A student shall be required to complete all the requirements for the award of the Bachelor or Master degree within such period as may be specified in the Regulations.

v. A student shall be required normally to attend every lecture, tutorial, studio and laboratory class. However, for late registration, sickness or other such exigencies, absence may be allowed as provided for in the Regulations.

vi. A student may be granted such scholarship/ studentship/ assistantship/ stipend, etc. and awarded such prizes and medals as may be specified in the Regulations in accordance with the directions of the Government of India/Government of NCT of Delhi and/or the decision of the AC/BoM.

vii. The procedure for the withdrawal from a program, rejoining the program, and all such matters as may be connected with the running of a program shall be such as may be specified in the Regulations.

viii. The procedure of conduct of examination, evaluation, the award of grades and the SGPA/CGPA, secrecy, and declaration of result shall be such as may be specified in the Regulations.

ix. The award of the Bachelor or Master degree to an eligible student shall be made in accordance with the procedure laid down in the Regulations.

x. The procedure for temporarily suspending or phasing out of a program, shall be such, as may be laid down in the Regulations.

xi. Notwithstanding anything contained in the above Ordinance, no Regulations shall be made in contravention of the decision of the AC/BoM in regard to the duration of the program, the number of studentships, the procedure of admission, the percentage of students of various categories. The Regulations for the undergraduate and post graduate degree programs can be prepared/ modified / amended from time to time and the same shall be approved by the AC.

xii. Subject to the provisions of the Act and Statutes and these Ordinances, the issues not covered in these Ordinances or in the event of differences of interpretation, the Vice Chancellor may take a decision, after obtaining the opinion of a Committee consisting of any or all the Deans of the University. The decision of the Vice Chancellor shall be final.

xiii. In special circumstances, the Vice Chancellor may, on behalf of the BoM, approve amendment, modification, insertion or deletion of an ordinance(s), which in his opinion is necessary or expedient for the smooth running of a program, provided that all such changes shall be reported to the BoM in its next meeting for ratification.

Regulations for the Undergraduate and Post Graduate degree programs

Delhi Technological University

(To be read alongwith the Ordinance 1(B), 2018 meant for the undergraduate and post graduate degree programs of Delhi Technological University for batches 2018-19 onwards)

(For batches 2018-19 and onwards)

Preamble

Delhi Technological University (DTU) is a non affiliating, teaching and research University at Delhi to achieve excellence in science, engineering, technology, management and allied areas and matters connected therewith or incidental thereto. The University enables students to face the wide-ranging changes taking place in the fields of science, technology, environment and management. This includes innovation, design, development, construction, production, managerial and entrepreneurial activities. The University lays great emphasis on assisting students in the development of national character, self-confidence, leadership and fostering an ecosystem for creativity and imagination.

R. 1(B).1. Short title and Commencement:

i. These Regulations are meant for the undergraduate and post graduate degree programs of Delhi Technological University for batches 2018-19 onwards and to be read with Ordinance 1(B), 2018 meant for the undergraduate and post graduate degree programs of Delhi Technological University for batches 2018-19 onwards.

ii. These Regulations shall come into force with effect from 1.08.2018.

R. 1(B).2. Definitions:

i. "**Applicant**" shall mean an individual who applies for admission to undergraduate/ post graduate degree programs

ii. "**AC**" **and** "**Council**" shall mean the Academic Council of the Delhi Technological University.

iii. "**Academic Program**" shall include a program of courses or any other component leading to undergraduate or post graduate degree.

iv. "**BoM**" shall mean the Board of Management of the University.

v. "**BoS**" shall mean Board of Studies of the Department.

vi. "**CGPA**" shall mean the Cumulative Grade Point Average.

vii. "**Coordination Committee**" shall mean the committee of the faculty members involved in a course.

viii. "**COE**" shall mean Controller of Examinations of the University.

ix. "**Course**" shall mean a curriculum component of the academic program identified by a designated code number, a title and specific credit assigned to it.

x. "**Course Coordinator**" shall mean a faculty member who shall have full responsibility

for the course; coordinating the work of faculty member(s) involved in that course, including examinations and the award of grades.

xi. **"CWS"** shall mean Class Work Sessional.

xii. **"Dean (UG)"** shall mean the Dean Academic (UG).

xiii. **"Dean (PG)"** shall mean the Dean Academic (PG).

xiv. **"Degree"** shall mean the Bachelor or Master degree of the University as may be approved by the BoM from time to time.

xv. **"Department"** shall mean a department of studies of the University

xvi. **"DSW"** shall mean the Dean of Students Welfare.

xvii. **"ETE"** shall mean End-Term Examinations

xviii. **"HOD"** shall mean Head of the Department/School

xix. **"Faculty Advisor"** shall mean a teacher nominated by the Department to advise a student on the courses to be taken by him/her and other matters related to the academic program.

xx. **"Grade Moderation Committee"** shall mean the committee appointed by the Board of Studies to moderate grades awarded by the Course Coordinators in different courses in a semester at a given level of a curriculum.

xxi. **"MTE"** shall mean Mid-Term Examinations

xxii. **"NRI NRI/PIO/FN category Student"** shall mean the student who is admitted

xxiii. against NRI/PIO/FN category.

xxiv. **"OBC"** shall mean the other backward classes as notified by the Government of India/ Government of NCT of Delhi from time to time.

xxv. **"PD"** shall mean the persons with disability as specified by the Government of India from time to time.

xxvi. **"PG"** shall mean the Post Graduate.

xxvii. **"PRE"** shall mean Practical Examinations

xxviii. **"PRS"** shall mean Practical Sessional

xxix. **"Registration" shall** mean registration for course or semester at the start of the semester of any program of the University.

xxx. **"SC/ST"** shall mean the Scheduled Castes and Scheduled Tribes as notified by the Government of India/Government of NCT of Delhi from time to time.

xxxi. **"Scheme of Teaching and Examination"** shall mean the scheme of teaching and examination as approved by the Academic council from time to time.

xxxii. **"School"** shall mean a school of studies of the University.

xxxiii. **"SGPA"** shall mean the Semester Grade Point Average.

xxxiv. **"Student"** shall mean a student registered for undergraduate or post graduate program.

xxxv. **"UG"** shall mean the Under Graduate.

xxxvi. **"University"** shall mean the Delhi Technological University.

xxxvii. **"UTTC"** shall mean University Time Table Committee.

Note: *'He', 'Him' and 'His' implies 'he/she', 'Him / Her' and 'his/her', respectively.*

R. 1(B).3 Board of Studies (BoS):

The Board of Studies (BoS) shall be a sub-committee of the AC, which shall consider all the academic matters related with the Department/School. It shall also consider and recommend to the AC the broad framework and policies related to the UG and PG degree programs offered by the University. The composition of BoS of the Department(s)/School(s) shall be as follows: Head of the Department/School (Chairperson), all Professors of the Department/School (Members), two Experts appointed by the Vice Chancellor (Members) and two Associate Professors of the Department/School by rotation (Members) for a period of two years. In the absence of adequate faculty in the Department/School, Vice Chancellor can constitute the BoS with faculty from other relevant disciplines.

R. 1(B).4 Undergraduate and Post Graduate Programs:

i The University offers Undergraduate and Post graduate programs of different durations in different disciplines as given in **Table 1**. The scheme of teaching and examination of these programs is given in ***Annexure 1A-1J*** respectively. The scheme of teaching and examination of a program may be amended/ modified in accordance with the approval of the AC.

Table 1: Broad Structure of UG and PG Programs

S. No	Program	Annexure
1.	B. Tech.	Annexure 1A
2.	B.Tech. under Continuing Education	Annexure 1B
3.	BBA	Annexure 1C
4.	BA/B.Sc.	Annexure 1D
5.	B. Des.	Annexure 1E
6.	M. Tech	Annexure 1F
7.	M. Tech (Part Time)	Annexure 1G
8.	MBA	Annexure 1H
9.	EMBA	Annexure 1I
10.	MA/ M.Sc.	Annexure 1J

ii The normal and maximum duration of the UG and PG programs is given in **Table 2**. The maximum duration for all the programs shall be counted from the date of initial registration. The maximum duration of the program shall include the period of withdrawal, absence and different kinds of leaves permissible to a student, but it shall exclude the period of rustication. The duration for these programs may be altered in accordance with the decision of the AC/ BoM.

Table 2: Duration of UG and PG Programs

S. No	Program	Normal Duration	Maximum Duration
1.	B. Tech.	4	7
2.	B.Tech. under Continuing Education	4	7
3.	B.Tech (Lateral Entry)	3	5
4.	BBA	3	5
5.	BA/B.Sc.	3	5
6.	B. Des.	4	7
7.	M. Tech	2	4
8.	M. Tech (Part Time)	3	5
9.	MBA	2	4
10.	EMBA	2	4
11.	MA / M.Sc.	2	4

R. 1(B).5 Admissions:

(i) The policy of admissions, the eligibility thereof, admission criteria and other issues pertaining to admission shall be such as may be approved by AC from time to time.

(ii) NRI/PIO/Foreign national either residing in India or abroad may be admitted to the UG and PG programs in accordance with the policy guidelines laid down by the AC from time to time.

R. 1(B).6 Starting a New Program:

i The University may start a new UG or PG program as approved by the BoM on the recommendation of the AC either on its own or on the initiative of a Department/School, and/or on the direction of the BoM.

R. 1(B).7 Semester System:

i. The academic programs in the University shall be based on semester system; Odd and Even semesters in a year with winter and summer vacations.

ii. A number of courses shall be offered in each semester. Each course shall have a certain number of credits assigned to it depending upon the academic load of the

course assessed on the basis of weekly/semester contact hours of lecture, tutorial, studio and laboratory classes, assignments or field study or self study.

iii. The courses offered in a semester shall be continuously assessed and evaluated to judge the performance of a student.

R. 1(B).8 Course Code:

Each course offered by the University shall be identified by a course code, normally consisting of a string of five alpha-numeric characters followed by a course title. The first two characters in a course code shall be capital letters identifying the responsible Academic Department/School offering the course. The next three characters are numerical digits: the first one normally specified the year of study and the last two digits specify the course number and the semester in which the course shall be offered. Normally odd number in the course code will indicate that the course will be offered in the odd-semester and the even number will indicate that the course will be offered in the even-semester of the year.

R. 1(B).9 Course Credits:

Each course shall have an integer number of credits, which reflects its weight. The number of credits of a course in a semester shall ordinarily be calculated as under:

i. **Lectures/Tutorial:** One lecture hour per week shall normally be assigned one credit. One hour of tutorial per week shall be assigned one credit. However, the credits may be adjusted further by taking into consideration the quantum of work required to be put in by a student for learning the course having two/three hours of contact every alternate week shall have one credit only.

ii. **Practical and Design Studio:** One laboratory or Design Studio hour per week shall normally be assigned half a credit. The courses having two/three hours of contact every alternate week shall have one credit only.

R. 1(B).10 Academic Registration:

i Every student shall be required to register in each semester on the scheduled date as per academic calendar of the University till the completion of the degree. If the student does not register on scheduled date he/she has to pay late registration fee notified from time to time upto a maximum of 10 working days. Registration in absentia may be permitted by the Dean (UG)/ Dean (PG). In absentia registration may be allowed only in rare cases such as illness or any other contingencies, at the discretion of the Dean (UG)/ Dean (PG).

ii In case, a student is proceeding on industrial training/internship, late registration may be allowed only up to a maximum of 10 working days after the scheduled registration date without late registration fee by the Dean (UG)/ Dean (PG).

R. 1(B).11 Course Registration:

i Every student shall be required to register for the courses that he/she wants to study for earning credits and his/her name will appear in the roll list of each of these courses. No credit shall be given if a student attended a course of which he or she has not registered. The performance of a student in all the courses, for which he/she has registered, shall be included in his/her grade card(s).

ii Student should first register for the courses in which he/she has been declared failed in the previous year/semester and then register for the remaining courses of the semester to make up the total required credits for that semester. However, a student of a program of more than 2 years duration shall not be allowed to register for the courses offered to students of third year, if he/she has not cleared all the courses of first year and a student of a program of more than 3 years duration shall not be allowed to register for the courses offered to students of fourth year, if he/she has not cleared all the courses of second year.

iii. All students of UG/PG program shall complete the registration procedure on a specified registration date as per academic calendar/ schedule notified from time to time.

iv. A student is advised to register the courses as specified in the scheme of teaching and examination of the program in each semester. In case the student is not allowed to register the courses of current semester due to backlog of course(s) of previous year(s), he/she may register for credits less than minimum credits depending on number of backlog of course(s) of previous year(s). However a student can register for a minimum and a maximum of credits as given in **Table 3**.

Table 3: Minimum and Maximum Permissible Credits

S. No	Program	Minimum Credits	Maximum Credits
1.	B. Tech.	16	32
2.	B.Tech. under Continuing Education	12	24
3.	BBA	16	32
4.	BA	16	32
5.	B. Des.	16	32
6.	M. Tech	12	24
7.	M. Tech (Part Time)	*	*
8.	MBA	16	32
9.	EMBA	16	32
10.	MA/M.Sc.	16	32

* Refer scheme of teaching and examinations of M.Tech Program.

v. A student shall have the option to add or delete courses from his/her registration during the first ten days of the semester as per Academic Calendar.

R. 1(B).12 Minimum Number of Students Required For An Elective Course:

An elective course in the department/school shall run if a minimum of 20 numbers of students register for it in a semester. However, the minimum number of students shall be decided as per guidelines laid by BoS for programs where the strength of batch of students is below 30.

R. 1(B).13 Program Advisor:

A Program Advisor shall be appointed by the Head of the Department who shall advise the students for registration.

R. 1(B).14 Course Coordinator:

Every course offered by a Department/School shall be coordinated by a Course Coordinator appointed by the Head of the Department/School. The Course Coordinator shall have full responsibility for the course. He/she shall coordinate the work of other faculty members involved in that course in respect of their participation in various activities related to the course including continuous evaluation of the students through tests, quizzes, assignments, mid-term and end-term examination and the award of the grades.

R. 1(B).15 Course Evaluation:

(i) A student shall be evaluated for his/her academic performance in a course through tutorials, practicals, design studio work, home work, assignments, term papers, field work/industrial training, seminars, quizzes as CWS and PRS, MTE, ETE and PRE as specified in the Scheme of teaching and examination.

(ii) The distribution of weights for each component shall be announced by the course Coordinator at the beginning of the course, subject to such stipulations as are given in the Scheme of Teaching and Examination for a given program.

(iii) The courses offered in a semester shall be continuously assessed and evaluated to judge the performance of a student.

(iv) The criteria for continuous evaluation of any subject shall be declared in the very first week of commencement of the classes.

(iv) Answer sheets of the test(s) and examination(s) cannot be written in pencil.

(v) Evaluation of Answer sheet(s) should not be in pencil.

(vi) A student can see his/her answer sheet(s) of MTE and the ETE and point out any discrepancy in its evaluation on a day fixed by the Course Coordinator/Chairman, Grade Moderation Committee. Objections will be entertained right then, and not even on the next day.

(vii) The answer sheets be disposed off by the Examination Branch after preserving them for six months only, except those which have some pending matter.

(viii) The answer sheets of the End-Term Examination shall not be shown to a student after finalization of the grades by the Grade Moderation Committee.

(ix) The industrial/field training shall normally be evaluated through the quality of work carried out, the report submission and presentation(s) as specified by the Department/ School from time to time. The project shall be evaluated normally by Mid-Term seminar(s), quality of work carried out, project report submitted and the viva-voce examination.

R. 1(B).16 Conduction of Examination:

(i) The examinations of various programs shall be conducted in a manner as prescribed and approved by AC.

(ii) Mid-Term Examination will be conducted by course coordinator and the faculty members concern during the slot notified by the COE.

(iii) While the paper is set, the Mid-Term Examination papers will not have any alternative, however 20-30% alternatives may be admissible in the End-Term Examination paper.

(iv) The End-Term Examination will be conducted by the COE.

(v) Evaluation process should be concluded within specified days from the end of the schedule of examination:

Mid-Term Examination – One week

End-Term Examination – Two weeks

(vi) A notification of slot/date/venue be issued by concerned faculty member under intimation to COE for showing answer sheets to the students. Both Mid-Term & End-Term answer sheets should be shown to the students by the concerned faculty member(s)/Evaluator(s).

(viii) Policy adopted by individual faculty member/ evaluator for evaluation of answer sheets should be uniform and consistent, and in case any moderation is done for the marks the same should uniformly be applied under intimation to COE.

R. 1(B).17 Grading System:

(i) The academic performance of a student shall be graded on a 10-point scale. For the award of grades in a course, all component-wise evaluation shall be done in marks. The marks of different components shall be reduced to relative weights of each component as per Scheme of teaching and examination and shall be added. Marks so obtained shall be out of 100 and the same shall be converted to grades.

(ii) The mean ($\bar{x}$) and the standard deviation (σ) of marks obtained of all the students in a course shall be calculated and used to convert the marks obtained (m) by a student into grades. The structure of grading will be as given in **Table 4.**

Table 4: Structure for Grading of Academic Performance

Letter grade	Numerical grade	Formula	Computation of grade cut off
O (Outstanding)	10	$m \geq \bar{x}+1.5\,\sigma$	The value of $\bar{x}+1.5\sigma$ to be taken into account for grade computation. The grade cut off will be $\bar{x}+1.5\sigma$ or 91% whichever is lower
A+ (Excellent)	9	$\bar{x}+1.0\,\sigma \leq m < \bar{x}+1.5\,\sigma$	The value of $\bar{x}+1.0\sigma$ to be taken into account for grade computation. The grade cut off will be $\bar{x}+1.0\sigma$ or 82% whichever is lower
A (Very Good)	8	$\bar{x}+0.5\,\sigma \leq m < \bar{x}+1.0\,\sigma$	The value of $\bar{x}+0.5\sigma$ to be taken into account for grade computation. The grade cut off will be $\bar{x}+0.5\sigma$ or 73% whichever is lower

B+ (Good)	7	$\bar{x}$+ 0.0 σ ≤ m <$\bar{x}$+ 0.5 σ	The value of $\bar{x}$+0.0σ to be taken into account for grade computation. The grade cut off will be $\bar{x}$+0.0σ or 64% whichever is lower
B (Above average)	6	$\bar{x}$-0.5 σ ≤ m<$\bar{x}$+0.0 σ	The value of $\bar{x}$-0.5σ to be taken into account for grade computation. The grade cut off will be $\bar{x}$-0.5σ or 55% whichever is lower
C (Average)	5	$\bar{x}$-1.0 σ ≤ m <$\bar{x}$-0.5 σ	The value of $\bar{x}$-1.0σ to be taken into account for grade computation. The grade cut off will be $\bar{x}$-1.0σ or 46% whichever is lower
P (Pass)	4	35 ≤ m <$\bar{x}$–1.0 σ	The lower grade cut off will be 35%
F (Fail)	0	m < 35	Less than 35%

In those subjects, where the total number of students is upto 30, the results in Grades shall be prepared on the basis of the actual performance of the student in the percentage scale and not on the basis of the formula approved for computation of grades.

(iv) The following are the general guidelines for the award of grades:

(a) All evaluations of different components of a course shall be done in marks for each student. The marks of various components shall be reduced to approve weights as given in Scheme of teaching and examination and added up to get total marks secured on a 100-Point scale. The rounding off shall be done only once and on the higher side.

(b) The method suggested in Table 4 shall be used for the award of grades with or without marginal adjustment for natural cut- offs.

(c) The provisional grades shall be awarded by the Coordination Committee of the course consisting of all the teachers involved in that course. The course coordinator shall have full responsibility for this purpose. The grades so awarded shall be moderated by grade moderation committee of the respective Department/ School.

(d) For a student to get passing grade, he / she will have to appear in End-Term Examination.

(v) The award of 'F' Grade

(a) The 'F' grades denote poor performance, i.e. failing course. 'F' grade is also awarded in case of poor attendance (see attendance Rules). 'F' grade secured in any course stays permanently on the grade card. The weight of 'F' grade is not counted in the calculation of the CGPA however, it is counted in the calculation of the SGPA.

(b) In case a student is awarded 'F' Grade in a Core paper, the student has to repeat

the course in the subsequent semester, when it is offered.

(c) In case a student is awarded 'F' grade in an Elective paper, the student may take the same course or any other course from the same category in the subsequent semester.

(d) In case a student is awarded a failing grade in the major / minor project, he/she shall have to repeat the course in the form of a new project. Such a student will have to work full time on the project for a minimum period of four months.

(vi) The award of 'I' grade

This refers to an 'incomplete' grade which is required to be converted into a regular letter grade. The guidelines for the award of 'I' grade is as follows:

a) If a student is absent during End-Term Examination of a course due to medical reasons or other special circumstances, he / she may apply for the award of 'I' grade to the COE through the Course Coordinator, provided that he / she has not been disqualified due to shortage of attendance. The concerned course coordinator shall have to be convinced about the extraordinary circumstances and shall have to certify the attendance record before this rarely used option to award 'I' grade is recommended.

b) The 'I' grade so awarded shall be notified by the COE.

c) The 'I' grade shall be converted into a proper letter grade and shall be sent to the COE after make-up examination is over and the requirements of the course are completed by the student.

d) In extra ordinary circumstances, the period of conversion of 'I' grade may be extended to the next semester, with the approval of the Dean (UG)/Dean (PG) on his own or on the recommendation of the Course Coordinator and the Head of the Department(s)/School(s).

e) In extra-ordinary circumstances, on the recommendation of the Dean (UG)/ Dean (PG), the Vice-Chancellor may order the award of 'I' grade to a student/ class or a batch of students taking a particular course. The conversion of 'I' grade into a regular grade or any other action shall be as per the approval of the Vice-Chancellor.

(vii) The letter grades awarded to a student in all the courses shall be converted into a semester and cumulative performance index called the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA), to be calculated as given below:

$$\text{S.G.P.A.} = \frac{\sum_{i=1}^{n} CixPi}{\sum_{i=1}^{n} Ci}$$

Where,

C_i= Number of Credits of the i^{th} course of a semester for which SGPA is to be calculated

P_i= Grade Point obtained in i^{th} course.

i =1, ...n, represent the number of course in which a student is registered in the concerned semester.

$$\text{C.G.P.A.} = \frac{\sum_{i=1}^{n} CixPi}{\sum_{i=1}^{m} Ci}$$

Where,

C_i = Number of Credits of the i^{th} course of a semester.

P_i = Grade Point obtained in i^{th} course. A grade lower than 'P' (i.e. grade point < 4) in a course shall not be taken into account.

i =1, ... m, represent the number of courses in which a student was registered and obtained a grade not lower than 'P' upto that semester for which CGPA is to be calculated.

(viii) At the end of the program, a student with CGPA of 8.0 and above shall be awarded 'First Division with Distinction' and a student with CGPA between 6.0 and 8.0 shall be awarded "First Division".

(ix) All the passing out students of a class shall be given ranks as **"Rank XXX in a class of YYY Students".**

R. 1(B).18 Grade Moderation Committee:

(i) The BoS of academic department(s)/School(s) will constitute the Grade Moderation Committee for all the Academic Courses under its purview. The Head of the Department/School shall be the Chairman of the committee, and other members shall consist of two Professors, two Associate Professors and two Assistant Professors of the department. This committee shall be responsible for adherence to the guidelines for the award of grades and shall include all the concerned Course Coordinators. The Chairman, Grade Moderation Committee shall be responsible for the display of grades in the department and for forwarding the final grades to the COE. The Chairman, Grade Moderation Committees shall also send the record-copies of the marks and the grades along with the statistical parameters for all the courses moderated to the COE. One copy of distribution of marks shall be sent to the COE along with grades by the Chairman, Grade Moderation Committee. The general guidelines for the moderation of grades are as follows:

a) The date of moderation shall be made a part of the Academic Calendar of the University.

b) Two-tier moderation be adopted, both for the subject and for the Semester (SGPA, CGPA), Minor adjustment shall be possible during moderation, particularly in the marginal cases. The Chairman, Grade moderation committee shall invariable retain a copy of the grades sent to Examination Section so that CGPAs may be calculated without having to make a reference to the Examination Section for this purpose.

c) All concerned faculty members should invariably be present for the moderation committee meeting. In case a faculty member is going out on University duty,

he/she shall hand over his/her inputs for moderation with a colleague, who shall present it, in the meeting.

R. 1(B).19 Scrutiny of Grades, Tabulation and Declaration of Results:

(i) A student may apply for scrutiny of grades to the Head of the Department/School, within three days from the date of display of grades. The Grade Moderation Committee and the Course Coordinator may check the entry of the weights from different components of evaluation and their addition. The results of scrutiny may lead to either a change in grade due to mistake(s) in any of the aspects scrutinized by the committee or the grade may remain unchanged. The results will be intimated to the COE within three days from the date of receiving the application in the department/school as per academic calendar.

(ii) In exceptional circumstances the grade(s) of a student or a number of students may be scrutinized by a committee constituted by the VC.

(iii) The COE shall organize the tabulation of grades and declaration of results. COE shall be the custodian of records related to examinations and results.

R. 1(B).20 Earned Minimum Credits and Minimum CGPA for the Degree:

(i) The credits for the courses in which a student has obtained 'P' (minimum passing grade for a course) grade or higher shall be counted as Credit Earned by him/her. A student, who has earned the required number of credits as specified in the curriculum he/she is registered for, is eligible for the award of the respective degree.

R. 1(B).21 Unfair Means

In case a student is found adopting or suspected of adopting unfair means before, during or after the examination, or lifting or copying of work(s) of someone else and inserting it in his class work submissions, Project, Dissertation etc. without proper acknowledgement, credit and reference, such penal action shall be taken by the University against the student as may be necessary and adequate to uphold the sanctity and integrity of the examination system and the credibility of the University. The general guidelines for a penal action for use of unfair means shall be prescribed at **Annexure 2.**

All the cases regarding use of unfair means practices in the examinations shall be reported and placed before the "Unfair Means Scrutiny Committee". The composition of the Unfair Means Scrutiny Committee shall be as follows: Dean (UG) (Chairperson), Dean (PG), DSW, Head of the concerned Department/School, Associate Dean/DR Academic (UG), Associate Dean/DR Academic (PG) (Members) and COE (Convener)

The COE shall convene the meeting of Unfair Means Scrutiny Committee from time to time as per requirement.

R. 1(B).22 Attendance, Absence, Leave and Withdrawals:

(i) All the students of UG/ PG programs are expected to attend every lecture, tutorial, practical or design studio class scheduled for them.

(ii) The students of UG/ PG program must have a minimum attendance of 75% of the total number of classes including lectures, tutorials and practicals, held in a subject in order to be eligible to appear at the End-Term Examination for that subject.

(iii) The Dean (UG)/ Dean (PG), authorized by the Vice Chancellor for this purpose may relax the minimum attendance upto 10% for reasons to be recorded. This relaxation may be granted on production of documents showing that the student was either busy in the authorized activities or suffering from any disease. The student should submit these documents to the Dean (UG)/ Dean (PG) through Chairman, BoS within seven days of resuming the studies.

(iv) Under exceptional circumstances, the Vice Chancellor may further relax the minimum attendance upto 5%.

(v) Attendance of the students shall be monitored and displayed during a semester as per the guidelines issued by the Dean (UG)/ Dean (PG).

R. 1(B).23 Make-up Examinations on Medical / Extra Ordinary Ground:

Students who have missed the Mid-Term Examinations and/or End-Term Examinations of a course(s) due to medical reasons or other special circumstance may be considered for a Make-up Examination on the clear cut recommendations of HOD considering the merit of the case. In case of End-Term Examinations Make-up Examinations will be allowed only if a student has not been disqualified earlier, due to shortage of attendance. The student shall make an application to the HOD, within ten working days from the date of the examination missed, explaining the reasons for his/her absence. Applications received after this period will not be entertained. The HOD shall forward all applications with his/her recommendations to COE who in turn shall seek approval from Dean (UG)/ Dean (PG). Further, there will be no make-up of the Make-up Examinations.

R. 1(B).24 Withdrawal

(a) Withdrawl from Course

A student who wants to withdraw from a course shall apply through the HOD to the COE within one week from the end of the Mid-Term Examination under the advice of his/her Program Advisor. If his/her request for withdrawal is granted, it will be recorded in the registration record of the student and the concerned Course Coordinator will be informed about it. The student will be awarded a withdrawal grade at the end of the semester.

(b) Semester Withdrawal:

In case a student is unable to attend classes for more than four weeks in a semester he/she may apply to the COE through HOD, for withdrawal from the semester, which shall mean withdrawal from all the registered courses in the semester. However, such application shall be made under the advice of the Program Advisor, as early as possible and latest before the start of the End-Term Examination. Partial withdrawal from the semester shall not be allowed.

R. 1(B).25 Termination of Enrolment:

(i) Due to Absence:

If a student registered in the first year of the program is continuously absent from the classes for more than four weeks without informing the Course Coordinators, the Coordinator shall immediately bring it to the notice of HOD of the concerned department/ school for informing the COE. The names of such students shall be removed from the

University rolls and such absence during first year will render the student ineligible for re-admission.

(ii) **On Academic Grounds:**

a) The enrolment of a student in a program shall stand terminated if he/she fails to earn 30% of prescribed credits in first year, as specified in the Scheme of teaching and examinations, at the end of first year.

b) The enrolment of a student shall stand cancelled on completion of maximum duration from the date of initial registration in the program.

b) A student whose enrolment has been terminated may appeal to the Vice Chancellor for reconsideration within fifteen days from the date of issuance of the communication of termination. If the appeal is allowed, his/her registration and enrolment shall be restored.

R. 1(B).26 Scholarship, Prizes, Medals and Merit Certificate:

(i) The University shall award the merit-cum-means (MCM) scholarships, University free studentship, SC/ST category University scholarship and other scholarships, award and prizes to the student of UG programs as may be approved by the AC/BoM. Other scholarships may be awarded by the University from the grant from individuals, trusts, organizations and the Governments with a view to provide financial assistance to needy students under the terms and conditions specified by the University. Announcements on these scholarships stating eligibility and the value of scholarships etc. shall be made by the University while inviting applications from time to time.

(ii) Those students, who have been punished for unfair means during MTE or ETE or in Seminars/ project/ etc. or for serious act of indiscipline shall not be awarded Merit-cum-Means Scholarship and other trust scholarship or Medals, Prizes and awards for that academic session only.

(iii) Student may draw scholarships from outside sources only if permitted by Dean (UG)/ Dean (PG).

R. 1(B).27 Phasing out of a Program:

The phasing out of a program may be considered by the AC on the recommendation of the BoS. Also, a program may be phased out by the AC if, consecutively for three years, the number of students registering for the program is less than 40% of the sanctioned intake of the students.

R. 1(B).28 Interpretation of Regulations:

In case of any dispute, difference of opinion in interpretation of these Regulations or any other matter not covered in these Regulations, the decision of the Chairman, AC shall be final and binding.

R. 1(B).29 Emergent Cases:

Notwithstanding anything contained in the above Regulations, the Chairman of the AC may, in emergent situation, take such action including insertion, suspension or modification of any Regulation(s) on behalf of the AC as he/she deems appropriate and report it to the next meeting of the AC for its approval.

Instruction for Penalty for Use of Unfair Means

1. The main instruction for the conduct of a student in the examination hall shall be printed on the cover page of the answer sheets. Any contravention of these instructions and the use any unfair means will render the student liable for punishment.

2. As soon as student is suspected by the invigilator having resorted to unfair means, his/her `answer-book shall be seized. The paper etc. duly signed by the invigilator found in possession of the student shall be attached with answer-book in his/her present. The student shall then be asked to complete part II of the prescribed form and sign it. This form shall than be endorsed by the Invigilator.

3. After completing all the above formalities, a fresh answer-book shall be given to the student for completing the examination.

4. After a particular examination is over, these answer-books (duly marked I, II) shall or delivered separately to the COE together with the report form duly completed in all respects.

5. All the cases reported in the category of unfair means shall be forwarded to the unfair means scrutiny committee which will inquire into them and submit its recommendation after laying down clearly the nature of the offence listed below to the Vice-Chancellor for consideration and necessary orders.

6. The action as given in table may be taken for different categories of offense under these Regulations.

Penalty for use of Unfair Means

CATEGORY	NATURE OF ACT	PUNISHMENT TO BE IMPOSED
I	• Found talking to another student during the examination hours. • Found talking to a person outside the examination hall. • Changing seat in the examination hall without permission. • Committing any breach of any direction given to the student. • Attempt to influence the examiner by an appeal in the answer-book. • Writing either the questions or solutions thereof on the question paper.	Warning with undertaking by the Student that S/he will not repeat such act during entire duration of the programme.

II	• Possession of cell phone or any other item of such type of communication in examination hall. • Intentionally tearing off the Answer Book/a part thereof or a continuation sheet. • Misbehaving with the Superintendent / Invigilator/ staff on duty or with any other candidate in or around the Examination Centre before, during or after the examination. • Leaving the examination room without the permission or without handing over the answer book or without signing the attendance sheet. • Found in possession of any written or Xerox notes or any printed materials or notes written on any part of the body/clothing or instruments or electronic device etc. or having notes written on University Furniture or drawing board or cover of the calculator etc which could be helpful to him/her in answering the paper or could be helpful to another candidate in that Examination Hall. • Using abusive cr obscene language in the answer book. • Copying or copied from any paper, book or note written on any part of his/her clothing or body or Furniture or instruments or Mobile phone or any other Electronic gadgets etc. • Consulting notes or books while being outside the examination hall during examination hours. • Allowed any other candidate to copy from his/her answer-book.	**Mid Term Examination** The Examination of the concerned paper to be cancelled and to be awarded ZERO marks in the concerned paper. **End Term Examination** The Examination of the concerned paper to be cancelled and to be awarded 'F' grade. The student shall be allowed to reregister for the cancelled paper in next academic year only.
III	• Smuggling in an answer -book or part of it, taking out or arranging to send out an answer-book or part of it. • Communicating or attempting to communicate directly or through someone else with the examiner or anybody connected with the University examination for influencing them regarding the award of marks. • Replacing his / her answer book or any page or continuation sheet with any other unauthorized book, page or continuation sheet during the course of examination. • Found in possession of an answer- book of some other student	**Mid Term Examination** All the papers of the Mid Term Exam to be cancelled and to be awarded ZERO marks in all the papers.

	• On being challenged /searched by the Superintendent, Invigilator or a staff on duty, swallows a note/ paper or runs with it or is guilty of causing disappearance or destroying any such material possessed by him/her. • Guilty of Writing deliberately another students' roll no. in his/her answer book.	**End Term Examination** All the papers of the End Term Exam to be cancelled and to be awarded 'F' grade in all the papers & shall re-register for all papers in next academic year only.
IV	• Gross misbehavior i.e. threatening with physical force to Superintendent, the Invigilator/ staff on duty working at the Examination Centre with any other candidate in or around the Examination Centre, before, during or after the Examination. • Disturbs the examination or attempts to do so • Impersonating for any other candidate in any examinations • Student is accused of Impersonation i.e. he /she managed to send somebody else in his / her place to take the examination. • Found guilty of serious misconduct in the examination hall.	All examinations of that Semester to be cancelled. The Student is not allowed to register in the immediate succeeding semester. The student shall register for the cancelled semester in the next academic year only . e.g. if a student is booked for UFM in 3rd semester • All papers of 3rd semester to be cancelled. • S/he can not register for 4th semester. • S/he shall re-register for 3rd semester in the next academic year only.
V	• Cases not covered under Category I to Category IV.	To be decided by the Vice Chancellor on the recommendation of UFMSC

Note:

(a) These Rules shall be applicable w.e.f. the date of notification to all the students of the University irrespective of the year of admission to which he/she belongs.

(b) In these Regulations the year means the academic year.

(c) In case of extenuating circumstances, the above punishment may be reduced by the Vice Chancellor depending upon the merits of the case.

(d) If student repeats any of the act as prescribed in various categories the act, the level of punishment may be raised to next level.

Preamble

The University offers following M.Tech. programmes (**Table-1**) leading to Master of Technology degree in different disciplines. The Academic Departments offer courses to the students of various disciplines. Academic curricula are so devised that a student of one discipline can take some courses of other disciplines offering choice based credit system (CBCS). Such flexibility helps a student to develop his core competence together with the interdisciplinary skills in the area of his/her interest.

Table-1. M.Tech. Programmes

S. No.	Department	Academic Program	Code
1.	Applied Chemistry	M. Tech. (Polymer Technology)	PTE
2.	Applied Physics	M. Tech. (Nano Science & Technology)	NST
3.	Biotechnology	M. Tech. (Bio Informatics)	BIO
4.	Biotechnology	M. Tech. (Biomedical Engineering)	BME
5.	Biotechnology	M. Tech. (Industrial Biotechnology)	IBT
6.	Civil Engineering	M. Tech. (Geotechnical Engineering)	GTE
7.	Civil Engineering	M. Tech. (Hydraulics & Water Resources Engineering)	HWE
8.	Civil Engineering	M. Tech. (Structural Engineering)	STE
9.	Computer Science & Engineering	M. Tech. (Computer Science & Engineering)	CSE
10.	Computer Science & Engineering	M. Tech. (Software Engineering)	SWE
11.	Information Technology	M. Tech. (Information Systems)	ISY
12.	Electronics and Communication Engineering	M. Tech. (Microwave and Optical Communication)	MOC
13.	Electronics and Communication Engineering	M. Tech. (Signal Processing & Digital Design)	SPD
14.	Electronics and Communication Engineering	M. Tech. (VLSI Design and Embedded System)	VLS
15.	Electrical Engineering	M. Tech. (Control & Instrumentation)	C&I
16.	Electrical Engineering	M. Tech. (Power System)	PSY
17.	Environmental Engineering	M. Tech. (Environmental Engineering)	ENE
18.	Mechanical Engineering	M. Tech. (Computational Design)	CDN
19.	Mechanical Engineering	M. Tech. (Production Engineering)	PRD
20.	Mechanical Engineering	M. Tech. (Thermal Engineering)	THE

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Salient Features of M.Tech Scheme

1. The M. Tech. programme will be of two/ three years duration respectively for Full Time / Part Time.

2. A student will be awarded the degree of Master of Technology after earning total 58 credits at the end of 4th / 6th semester;

3. In each of first and second semester of all M.Tech. programmes, there will be two 4 credit core courses, three elective courses (one each of 4 credit, 3 credit, 2 credit respectively);

4. For M.Tech Part Time Programme, student will study Group A (Program Core 1 & 2) in 1st semester, Group C (Program Core 3 & 4) in 2nd semester, Group B (Three electives courses one each of 4,3 and 2 credits) in 3rd Semester, Group D (Three elective courses one each of 4,3 & 2 Credits) in 4th semester, Group E in 5th semester and Group F in 6th semester.

5. In second year, there will be two parallel tracks, namely –
   (1) Research Track – Track I
   (2) Coursework track- Track II;

   Research Track : In Research track, the students will be required to publish research paper as per the approved research publication policy of the university. The student will be awarded 24 credits after publishing research paper.

   Coursework Track : In Course work track, the students will be required to take 1 core course (Major Project 1) and three elective courses (one each of 4 credit, 3 credit, 2 credit respectively) in third/ fifth semester. In fourth/ sixth semester, the students will be required to take 1 core course (Major Project 2).

6. A student must earn at least 08 credits from 04 credit elective courses and at least 06 credits from 03 credit elective courses from a basket of electives specific to that program. The remaining elective credits may be earned from electives offered for other programs including MOOCs. In case of MOOCs only 02 credits per MOOC course will be considered;

7. In first semester of every M.Tech. Programme, a seminar has been offered as a two credit elective course;

8. In second semester of every M.Tech. Programme, a minor project has been offered as a three credit elective course;

9. Keeping in view the audit courses in the model PG curriculum of AICTE, 2 credit elective courses under Group B and Group D have been offered. These courses are general in nature and supposed to add value to the M. Tech. programme. These courses will be called university electives and coordinated at the level of Dean (Acad-PG). A student may opt any one of these electives against 2 credits elective courses offered under Group B and Group D each;

10. The following alphanumeric coding scheme has been adopted:

Core Courses : XXXYMN
Elective Courses : XXXYCMN

XXX abbreviates a particular M. Tech. programme, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year),

C – credit of the course (4/3/2), MN – Subject code (Odd number for odd semester and even number for even semester courses.

11. To facilitate slow and fast learners, a student can register minimum 12 credits and maximum 24 credits in a semester; out of these registered credits, core courses being offered in the specific programme must be registered.

M. Tech. Scheme Structure

SEMESTER I				
	COURSES	**CREDITS**	**TYPE**	**TOTAL CREDITS**
Group A	Program Core- 1	4	Core	17
	Program Core- 2	4	Core	
Group B	Elective 1	4	Elective	
	Elective 2	3	Elective	
	Elective 3/ University Elective I	2	Elective	
SEMESTER II				
	COURSES	**CREDITS**	**TYPE**	**TOTAL CREDITS**
Group C	Program Core- 3	4	Core	17
	Program Core- 4	4	Core	
Group D	Elective 4	4	Elective	
	Elective 5	3	Elective	
	Elective 6/ University Elective II	2	Elective	
SEMESTER III				
Group E	Track 1*			12
	Research Project	12	Core	
	Track 2			
	Elective 7	4	Elective	
	Elective 8	3	Elective	
	Elective 9	2	Elective	
	Project-1	3	Core	
SEMESTER IV				
Group F	Track 1*			12
	Research Project	12	Core	
	Track 2			
	Project 2	12	Core	
Total Credits				**58**

DEPARTMENT OF APPLIED CHEMISTRY

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Polymer Technology)

Programme Specific Outcomes

1. Highly valued technocrats competent to take up the challenging positions in industry, academia and government sectors.
2. Ability to execute new ideas with established principles of polymer technology in the field of Research & Devlopment in India and abroad
3. Ability to adapt continuously changing techniques and play pivotal role in the process of sustainable development of society

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN POLYMER TECHNOLOGY (PTE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	PTE501	Polymer Chemistry	Core	4	3	0	2	15	25	20	40	-	17
	2	PTE503	Polymer Structure and Properties	Core	4	3	0	2	15	25	20	40	-	
Group B	3	PTE5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	PTE5301/5303/.....	Elective 2	Elective	3	3	0	0	20	0	30	50	-	
	5	PTE5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	PTE502	Polymer Processing	Core	4	3	0	2	15	25	20	40	-	17
	2	PTE504	Polymer Testing and Characterization	Core	4	3	0	2	15	25	20	40	-	
Group D	3	PTE5402/5404/.....	Elective 4	Elective	4	4	0	0	20	-	30	50	-	
	4	PTE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	PTE5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group E	Track 1													
	1	PTE651	Research Project	Core	12	0	0	12	0	-	0	100	-	12
	Track 2													
	1	PTE601	Major Project I	Core	3						40	60		12
	2	PTE6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	PTE6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	PTE6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													
	1	PTE652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	PTE602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	PTE5401	Plastic Technology	Elective	4	3	0	2	15	25	20	40	-
	2	PTE5403	Rubber Technology		4	3	0	2	15	25	20	40	-
	3	PTE5405	Fiber Technology		4	3	0	2	15	25	20	40	-
		PTE5407	Resin Technology		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	PTE5301	Polymer Degradation	Elective	3	3	0	0	20	-	30	50	-
	2	PTE5303	Polymer Recycling		3	3	0	0	20	-	30	50	-
	3	PTE5305	Environment Assessment of Polymer		3	3	0	0	20	-	30	50	-
	4	PTE5307	Green Polymers		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	PTE5201	SEMINAR	Elective	2	2	0	0	0	-	0	100	-
	2	PTE5203	Engineering Concepts in Polymers (for Science students)		2	2	0	0	20	-	30	50	-
	3	PTE5205	Chemical Concepts in Polymers (for Engineering Students)		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	PTE5402	Polymer Blends and Composites	Elective	4	4	0	0	20	0	30	50	-
	2	PTE5404	Membrane Technology		4	4	0	0	20	0	30	50	-
	3	PTE5406	Adhesive and Coating Technology		4	4	0	0	20	0	30	50	-
	4	PTE5408	Tyre Technology		4	4	0	0	20	0	30	50	-
	5	PTE5410	Paint Technology		4	4	0	0	20	0	30	50	

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	PTE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	60	
	2	PTE5304	Packaging Technology		3	3	0	0	20	-	30	50	-
	3	PTE5306	Biomedical Applications of Polymers		3	3	0	0	20	-	30	50	-
	4	PTE5308	Polymers in Food and Healthcare Applications		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	PTE5202	Commercialization of Polymers and Chemical Technology Products	Elective	2	2	0	0	20	-	30	50	-
	2	PTE5204	Engineering economics and Entrepreneurship		2	2	0	0	20	-	30	50	-
		PTE5206	Statistical Quality control		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	PTE6401	Rheology	Elective	4	3	0	2	15	25	20	40	-
	2	PTE6403	Polymer product and Die Design		4	3	0	2	15	25	20	40	-
	3	PTE6405	Additives and Compounding		4	3	0	2	15	25	20	40	-
	4	PTE6407	Extrusion and Injection Molding		4	3	0	2	15	25	20	40	-
	5	PTE6409	Nonwoven Technology		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	PTE6301	Specialty Polymers	Elective	3	3	0	0	20	-	30	50	-
	2	PTE6303	Application of nanomaterials in Polymers		3	3	0	0	20	-	30	50	-
	3	PTE6305	Inorganic polymers		3	3	0	0	20	-	30	50	-
	4	PTE6307	Biosensors		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	PTE6201	Practical Training in Industry	Elective	2	2	0	0	20	-	30	50	-
	2	PTE6203	Research Exploration		2	2	0	0	20	-	30	50	-
	3	PTE6205	Special Lectures in Polymers and Industrial Visits		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

PTE501 Polymer Chemistry

Introduction: Nomenclature, classification of polymers, general characteristics of polymers, ring opening polymerization, coordination polymerization, cyclopolymerization. Step-Growth Polymerization: General characteristics & chemistry of condensation polymerization, Ring vs Chain formation, Requirement of high conversion & high molecular weight polymer, step copolymerization, polymerization kinetics: concept of equal reactivity of functional group, non-linearity in step growth polymerization, step growth polymerization other than polyesterification, catalyzed vsuncatalysed, kinetics analysis of polymerization of A-A with B-B' and non-stoichiometric polymerization. Chain growth polymerization: General characteristics & chemistry of chain growth polymerization, Ionic vs radical polymerization, nature of radical chain polymerization, effect of substituents, constitutional isomerism: experimental evidences and synthesis; Initiator and initiation systems, initiator efficiency, types of radical initiation; kinetic expression for rate of initiation and polymerization. Copolymerization: General considerations, types of copolymers, significance of copolymerization, kinetic equation, copolymerization behavior for alternate, random, block, graft copolymer, Polymerization techniques-solution, emulsion, bulk, suspension. Purification techniques: Solvent-Nonsolvent extraction, isolation, centrifugation

Suggested Books:

1. F.W. Billmeyer, Textbook of Polymer Science, John Wiley, 2008.
2. V.R. Gowarikar, Polymer Science, New Age International, 2016.
3. G. Odian, Principle of Polymerization, Wiley, 2004.
4. M.P. Stevens, Polymer Chemistry, Oxford University Press, 1999.

PTE503 Polymer Structure and Poperties

Polymer molecular weight and its importance, molecular weight and its distribution method of determination of different molecular weights, number average, weight average, viscosity average, z- average molecular weights, polydispersity index and its significance.

Polymer Structure analysis, configuration, conformation of polymers, structure and properties of amorphous, semi crystalline and cross-linked polymers, crystal morphologies: unit cell structure, extended chain crystals, chain folding, lamellae, and spherules

Thermal properties of polymers, glass transition temperature (Tg), melting temperature (Tm), softening temperature (Ts) degradation temperature, flow temperature and tack temperature, flex at lower temperature, factors affecting the Tg and Tm of polymers, thermal analysis of polymer by dilatometer, TGA, DSC, DTA and HDT,determination of crystallinity and crystallization Kinetics,

Types of fluids, viscoelastic properties of polymer, basics of rheological characteristics, experimental determination, mechanical models (Maxwell model, Kelvin-Voiget model) determination of rheological properties through viscometers and DMTA.

Mechanical properties of polymers strength (creep, fatigue, stress relaxation tensile, flexural and compressive), hardness, resilience, impact properties, factors affecting these properties, methods of determination of these properties,

Optical properties of polymers (haze, glaze, refractive index).

Suggested Books:

1. P. Ghosh, Polymer Science & Technology, Tata McGraw Hill, 2001.
2. Wunderlich, Thermal Analysis of Polymeric Materials, Springer, 2005.
3. V. Shah, Handbook of Plastic Testing & Failure Analysis, Wiley Inter-science, 2006.
4. Mathur, Bhardwaj, Testing & Evaluation of Plastics, Allied Publishers Pvt Ltd, 2003.

PTE5401 Plastic Technology

Manufacturing, properties and applications of Polyethylene, Polypropylene, Polyisobutylene, Polystyrene, Modified Polystyrene, Polyvinyl chloride, Polyvinyl acetate, PVA, PEG, Polyacrylic acid, Polyacrylates, Poly(methyl methacrylate), Polyacrylamide, Polyacrylonitrile, Polyesters: Poly(ethylene terephthalate), Polybutylene terephthalate; Polycarbonates; Polyamides; Polyimides; Polyacetals; PU; Silicones, Polyphenylene sulfide (PPS), Polysulfones, Polyaryletherketone (PEEK, PEKK, *etc.*), Polyetherimide (PEI), PTFE, Recent advancements in polymer technology.

Suggested Books:

1. Brydson's Plastics Materials, Eighth Edition, Butterworth-Heinemann/Elsevier, 2016.
2. Feldman & Barbalate, Synthetic Polymers, Chapman & Hall, 1995.
3. Braun et al, Polymer Synthesis: Theory and Practice, Springer International , 2013.

PTE5403 Rubber Technology

Introduction to rubber, theory of rubber elasticity, thermodynamics of rubber elasticity, morphology of rubber, structure property relationship in rubbers, non-elastomeric properties, chemical reactivity solution properties, theory of reinforcement and crosslinking- mechanism and practice of sulfur vulcanization and non-sulfur vulcanization (peroxide, metal oxides and other special curing systems) silicone rubber, thermoplastic elastomers, speciality elastomers. Natural Rubber: Various sources of natural rubber, history and development of HeveaBrasiliensis as the commercial source of natural rubber, chemical formula, molecular weight distribution, concept of Sol, Gel, microgel and macrogel. natural rubber from latex, field latex composition, methods of concentration and stabilization of latex, effect of electrolyte and protein, processing of latex into sheet and pale crepe rubber. Chemistry and technology of synthetic rubbers –NR, SBR, nitrile, polybutadiene, polychloroprene, ethylene propylene, polysulfide, butyl, silicon / fluorosilicon, polyurethane, fluoroelastomer, ECO, TPO/ TPE,TPV, CPE, CSM, Acrylate rubbers. Rubber additives and compounding: Pre-vulcanized latex, vulcanizing agents, activators, accelerator, fillers, softeners, antioxidants/antiozonants, peptizers, retarders, resin, flame retardants, colors and pigments, tackifying agents, blowing agents, bonding agents, compound development and compounding of rubbers. Manufacture of latex products by impregnation and spreading process, casting impregnation, dipping process, latex coatings, latex cement and adhesives, latex thread and coir, latex foam, manufacture of rubber products, manufacture of rubber products as tubes, hoses and footwear

Suggested Books:

1. M. Morton, Rubber Technology, Springer Publications, 2013.
2. S.N. Chakravarty, Rubber Technology and Manufacture of Rubber Products, Polym Consultant, 2013.
3. C M Blow, Rubber Technology and Manufacture, Numbers Butterworth London, 1982.

PTE5405 Fiber Technology

Introduction to fibres and basic terminology, characteristics of fibre forming polymers, classification of fibres, properties and structure of natural fibres. Principles of fibre spinning, melt spinning, solution spinning, gel spinning, electro-spinning, effect of process parameters of each spinning techniques on structure and properties of fibres. Post spinning operations, principles and effects on properties of fibres, drawing, heat setting, spin finish, texturing, top to tow converters. Manufacturing, properties and uses of viscose rayon, acetate rayon, polyester, polyamide, polyacrylonitrile, polypropylene, aramides, polyurethane, high density polyethylene fibres, Manufacturing process of bicomponent fibers, hollow fibers, micro denier fibres. Applications of fibres in the technical textiles such as medical, geotextiles and filtration

Suggested Books:

1. S.P. Mishra, A Textbook of Fibre Science and Technology, New Age Publication, 2014.
2. V.B. Gupta and V.K. Kothari, Manufactured Fibre Technology, Springer, 1997.
3. Lewin and Prestone, Handbook of Fiber Science and Technology, Vol. III, Dekker, 1996.

PTE5407 Resin Technology

Resins and resinous state, classification, natural and synthetic resins, composition, purification and uses, modification of natural resins. Polyester resins: Curing of resins, catalysts and accelerators, water reducible polyesters, high solid polyesters/ polyesters for powder coatings, moulding compositions, DMC, SMC, fibre and film forming compositions

Phenolic resins: Basic components, theory of resinification, reaction mechanism, effect of ratio of reacting components and pH on reaction mechanism, Novolacs and Resol, curing and moulding, applications of phenolic resins. Amino Resins: Synthesis and properties of UF and MF resins, theory of resinification, reaction mechanism, effect of pH on the reaction mechanisms, curing and moulding, applications of amino resins. Epoxy resins: Manufacturing and applications. Alkyd Resins: Functionality concepts, use of polyfunctional acids and alcohols, phthalic acid resins, Manufacturing, types of modifications and properties of modified alkyd resins, Applications of alkyd resins.

Suggested Books:

1. B. Golding, Polymer and Resins; Their Chemistry and Chemical Engineering, D. Van Nostrand Company Inc, 2012.
2. Seymour and Carraher, Polymer chemistry, Marcel Dekker, 2003.
3. Synthetic Resins Technology Handbook, NIIR Board of Consultants & Engineers, 2005.

PTE5301 Polymer Degradation

Basics of polymer degradation: Introduction to polymer degradation, analysis of polymer degradation, importance and limitations of polymer degradation for industry and society, factors of polymer degradation. Thermal and photo-degradation: Mechanism, random scission and sequential elimination, structure stability relationship, photochemical reactions, types of radiations and their effects, quantum yield, role of stabilizers. Mechanical degradation: Mastication, mechanochemical degradation, ultrasonication, degradation due to shear (turbulant flow, shaking). Chemical degradation: Solvolysis, oxidative degradation, ionic degradation, weathering, stress induced chemical alteration of polymers. Biological degradation: Modes of biodegradation, enzymatic degradation of biopolymers & synthetic polymers

Suggested Books:

1. Hamid, Handbook of Polymer Degradation, Second Edition, Taylor & Francis, 2000.
2. Albertsson, Degradable Polymers, Recycling, and Plastics Waste Management, CRC Press, 1995.
3. N.S. Allen, M. Edge, Fundamentals of Polymer Degradation and Stabilization, Elsevier, 1992.

PTE5303 Polymer Recycling

Basics of polymer waste: Introduction to polymer waste, definitions of related terms – waste polymer, industrial polymer waste, postconsumer polymer waste, nuisance polymer, scrap polymer, management of polymer waste - 5 R's. Separation methods: Size reduction, separations using physical properties, recycling codes. wet separation process, electro dynamic separation. Recycling process: Primary, secondary, tertiary and quaternary recycling, Recovery and value addition of waste of PVC, PET, PMMA, HDPE, LDPE, PS, rubber reclaiming, Polymer waste management: Case studies; future trends of sustainable development

Suggested Books:

1. J. Scheirs, Polymer Recycling: Science, Technology and Applications, Wiley, 1998.
2. R. Francis, Recycling of Polymers: Methods, Characterization and Applications, Wiley, 2016.
3. F.L. Mantia, Handbook of Plastics Recycling, Smithers Rapra Publishing, 2002.

PTE 5305 Environmental Impact Assessment of Polymers

Polymer and plastic Industries: Global and Indian scenario, accumulation of polymer waste in the natural environment, economic and environmental impact of polymer waste, polymer product sustainability, objectives of environmental impact assessment (EIA). Pollution and hazards related to plastics, loading of toxic chemicals from plastics into soil and water (including additives, flame retardants, anti-oxidants etc.), BS standards regarding limits of these chemicals in effluents; REACH, Effects of plastic debris in the environment and on wildlife. Impact of degradation and recycling of polymeric materials on Environment, disposal process of polymeric materials. Environmental Impact Analysis: Law and statutes in India; Environment consciousness; Environment education & awareness; Environmental policies, legislation & code of protection. Organizations involved in plastic waste management; Case studies; methods of sustainable development.

Suggested Books

1. T. Hamaide, R. Deterre, J.-F. Feller Environmental Impact of Polymers, Wiley, 2014.
2. R. Francis, Recycling of Polymers: Methods, Characterization and Applications Wiley, 2016.
3. A. Azapagic, A. Emsley, I. Hamerton, Polymers: The Environment and Sustainable Development, Wiley, 2003.
4. S. Divan, Environmental law and policy in India, Oxford University Press, 2001.

PTE5307 Green Polymer

Introduction to green chemistry, contributions of paul anastas, roger sheldon (E-Factor), and barry trost (atom efficiency), green polymers, need for green polymers, limitations/ obstacles in the pursuit of the goals of green polymer chemistry, basic principles of green chemistry, inception of green

chemistry – awards for green chemistry – international organizations promoting green chemistry. Definition of biopolymers and types of biopolymers, definition of bioplastics, types of bioplastics, such as starch based, cellulose based plastics and some aliphatic polyesters (PLA, PHB), polyamides, bio-based composites from soybean oil and chicken feathers, bio-derived polyethylene and genetically modified bioplastics. Naturally occurring polymers: Polysaccharides, protein, polyisoprene, polynucleotides, lignin. Designing of polymers using green principles; future trends in green polymer chemistry, oxidation reagents and catalysts; biomimetic, multifunctional reagents; combinatorial green chemistry; Proliferation of solvent less reactions; green polymer chemistry in sustainable development

Suggested Books:

1. V.K. Ahluwalia Green Chemistry: Environmentally Benign Reactions, CRC Press, 2008.
2. V.K. Ahluwalia, M. Kidwai, New Trends in Green Chemistry, Kluwer Academic, 2004.
3. M. Doble, A.K. Kruthiventi, Green Chemistry and Engineering, Elsevier, 2007.

PTE5201 SEMINAR

PTE5203 Engineering Concept in Polymers (for Science Students)

Vector and tensor quantities, different mathematical operations related to vector and tensor quantities, basic matrix operations. Fluid Mechanics: Introduction, basic concepts, definition, Newtonian and non-Newtonian fluids, equation of continuity and equation of motion. Industrial reactors, batch and continuous reactors (CSTR, PFR), reactors used in heterogeneous reactions, Ideal and non-ideal reactors, special features of the reactors used in polymerization reactions. Mechanical operations used in polymer industry: different types of crushers and grinders used for particle size reduction of fillers, mixing operation, design parameters of mixtures, conveyers system, motor, gear.

Suggested Books:

1. W.L. McCabe, J.C. Smith, P. Harriott, Unit operations of chemical engineering, McGraw Hill, 2014.
2. Levenspiel, Chemical Reaction Engineering, Wiley-Blackwell, 2002.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 2014.

PTE5205 Chemical concept in Polymers (For engineering Students)

Stereochemistry: Geometrical isomerism, E & Z nomenclature; conformational isomerism of ethane, n-butane, cyclohexane; elements of symmetry, optical isomerism, racemic modification, R and S nomenclature. Fundamentals of organic reactions: Types of reactions, addition, substitution, elimination, condensation, rearrangement; reactive intermediates, carbocations, carbanions, free radical (peroxides, AIBN, Persulphates) Spectral methods of structure determination I: Electromagnetic radiation, characteristics of EMR, dual nature; UV-visible spectroscopy, principle, instrumentation and applications, (qualitative and quantitative analysis)

IR spectroscopy: Principle, instrumentation and applications. Spectral methods of structure determination II: NMR spectroscopy; NMR active nuclei, principles and applications; chemical shift; Shielding & deshielding effects; number & splitting of signals; coupling constants. X-ray diffraction; basic principle and instrumentation; Mass spectrometry; principle, instrumentation and applications; molecular ion; even-electron rule; nitrogen rule; fragmentation: type and pattern. Structure elucidation using spectral data

Suggested Books:

1. D. A. Skoog, F.J Holler Principles of Instrumental Analysis, Sengage Learning, 2014.
2. M. Boyd, Organic Chemistry, 7e.,Pearson Education, 2007.
3. M.B. Smith, J. March, Advanced Organic Chemistry, John Wiley & Sons, 2007.
4. R.M. Silverstein, Spectrometric Identification of Organic Compounds, John Wiley & Sons, 2005.

SEMESTER II

PTE502 Polymer Processing

Importance of polymer compounding, additives used in compounding their functions in compounded product, mixing techniques

Working principle of single screw extruder, twin screw extruder, vent extruder, process of manufacturing films, tubes, rods, laminates, coatings. Compression molding machine: types, principles of operations, molding cycle, meaning of terms bulk factor and flow properties as applied to molding materials, the interplay of heat, pressure, friction, catalysts etc. for thermosetting materials; trouble shooting. Injection molding machine-machine description study, types and limitations, working principles, process variables, trouble shooting, gas assisted injection molding, structural foam molding, reaction injection molding process, their industrial applications; trouble shooting. Blow molding process, principles and description of blow mold, extrusion &injection stretch blow molding, parison control, trouble shooting. Miscellaneous processing methods: casting, rotational molding, decoration of polymers, working principles of calendaring and thermoforming process

Suggested Books

1. Harper, Handbook of Plastic Processes, Wiley Interscience, 2006.
2. Tadmor & Gogos, Principles of Polymer Processing, Wiley Interscience, 2013.
3. R.J. Crawford, Plastics Engineering, Butterworths, 2013.
4. J.A.Brydson, Plastic Materials, Butterworth-Heinemann, 1999.

PTE504 Polymer Testing & Characterization

Application of national and international standards, BIS, ISO, ASTM for testing and their significance, identification of common polymers by simple tests. UV-visible, IR and Raman spectroscopy: Applications in polymer characterization, NMR spectroscopy in liquid and solid phase (^{1}H and ^{13}C): Applications in polymer characterization, Mass spectrometry, separation techniques (GC, LC), structure elucidation of monomers and corresponding polymers and polymeric materials based on spectroscopic data. X-Ray diffraction method, scanning electron microscopy, transmission electron microscopy, and atomic force microscopy, testing of electrical properties, tribological properties permeability and weatherability of polymers

Suggested Books

1. P. N. Cheremisinoff, Polymer Characterization, Elsevier, 1996.
2. Kitayama, Tatsuki, Hatada, Koichi NMR Spectroscopy of Polymers, Springer, 2004.
3. R. Yang. Analytical Methods for Polymer Characterization, CRC Press, 2018.

PTE5402 **Polymer Blends and Composites**

Polymer blends classification, principles of polymer compatibility, different theories of predicting compatibility, factors governing compatibility, compatibilizers, property achieved by blending, methods of blending, characterization of blends, properties of miscible and immiscible blends, their properties and identifications, commercial polymer blends and their properties, morphology of blends and its determination. Introduction to rheology of polymer blends, its relevance in processing, rheology phase morphology relationships and their relevance, concept of rubber toughening, and its application commercial products. Classification of composites, particulate and fibrous composites, Introduction to reinforcing materials, nano-fillers based composites, importance of composite materials in engineering applications. Fabrication of continuous and short fiber reinforced composites and particulate reinforced composites, different fabrication methods, their operating parameters, benefits and limitations, Industrial/commercial applications. Characterization of composite materials, identification of key properties of a composite product/material, mechanical, thermal, morphological physical and chemical testing methods, non-destructive testing of polymer composites, recent advancement in polymer composites

Suggested Books:

1. D.R. Paul, Polymer Blends, Vol. I & II, Academic Press, 1978.
2. Chawla, Composite Materials: Science & Engineering, Springer, 2012.
3. Kulshreshtha & Vasile, Handbook of Polymer Blends & Composites, vol 1, Rapra Tech Ltd, 2002.
4. A.P. Gupta, M.C. Gupta, Polymer composite, New Age publication, New Delhi, 2018.

PTE5404 **Membrane Technology**

Introduction of membrane based separation methods, classification, materials used for membrane manufacturing, their benefits and limitations, membrane preparation methods, phase inversion, symmetric and asymmetric membranes, composite membranes, inorganic membranes, sol-gel method. Mass transport mechanism of membrane based separation processes, fick's law, non-equilibrium thermodynamics based models, multicomponent mass transfer, concept of concentration polarization and membrane fouling. Concentration and pressure driven membrane based processes: reverse osmosis, liquid membranes, ultrafiltration, nano-filtration, gas separation, transport mechanism, material used, membrane properties, applications, advantages and limitations. Other separation processes: electro-dialysis, pervaporation, membrane distillation, membrane contractors, membrane reactors, forward osmosis and pressure retarded osmosis.Designing of industrial scale membrane based separation units, membrane modules, spiral wound modules, hollow-fiber and tubular modules, their benefits, limitations, modeling of membrane based modules

Suggested Books

1. W. S. Winston Ho, K.K. Sirkar, Membrane handbook,Van Nostrand Reinhold, New York, 1992.
2. R.W. Baker, Membrane Technology and Application, John Wiley & Sons Ltd, 2004.
3. J. Mulder, M. Mulder, Basic Principle of Membrane Technology, Springer, 2013.
4. Journal of Membrane Science (Journal) Publisher: Elsevier BV

PTE5406 **Polymer Adhesives**

Fundamental aspects of adhesion technology: Introduction to adhesives, theories and types of adhesions, process of bonding, mechanism of adhesion, mechanical interlocking, inter-diffusion, adsorption and surface reaction, electrostatic attraction. Classification of adhesives: Solvent responsive adhesives, heat sealing, pressure sensitive, chemically reactive Structural adhesives: Epoxies, PF, UF and MF; non-structural adhesives: natural rubber (NR), polyester based (unsaturated polyester), silicone, acrylics (reactive, aerobic, anaerobic and cyano acrylics), polyurethane, poly vinyl acetate and ethylene vinyl acetate copolymer. Preparation of adhesives: Animal glue, protein adhesives, starch adhesives, synthetic resin adhesives, rubber based adhesives, cellulose & silicate adhesives. Industrial application of adhesives: Adhesives in electronics, wood and automotive industry, Dentistry and drug delivery, safety measures in manufacturing and applications of adhesives. Recent advancements in polymeric adhesives, application of nano-fillers in polymeric adhesives.

Suggested Books:

1. Bieleman, Additives for Coatings, Wiley, 2000.
2. Pizzi & Mittal, Handbook of Adhesives Technology, Marcel- Dekker, 2003.

PTE5408 **Paint and Coating Technology**

A general introduction to paints and coatings, history of paint/coatings, components of paint, pigments for paint, pigment classification, manufacture of pigments; additives for paint, anti-corrosive pigment enhancers, antifoams, ant settling agents, antiskinning agents, solvents, thinners, and diluents, solvent effects on viscosity. Paint manufacturing process, equipment used for pigment paste manufacturing, high-speed mixers (HSD, HLM), different types of grinders used in paint industries. Liquid organic coatings, film formation, curing, dry film properties, coating selection, vinyl epoxies, urethanes, alkyds, oil-based paints, water-based paints, furans, phenolics, fluorocarbons, silicones, PVC coatings, application of coatings. Coating process: Immersion plating, impregnated coating, metallized coating, vapour deposition, chemical conversion coating, organic coating, Film formation, Polymer film forming mechanism. Testing methods: Viscosity, finished film testing, test standards, mechanical testing, humidity Testing, salt spray testing, QUV testing, temperature–humidity testing, color matching and color control. Health hazards and environmental aspects, safety measures in manufacturing and applications of paints & coatings

Suggested Books:

1. R. Talbert, Paint Technology Handbook, CRC Press, 2008.
2. J. Bentley, G.P.A. Turner, Introduction to Paint Chemistry and principles of paint technology, 4th Ed, CRC Press, 1997.
3. Paints Pigments Varnishes and Enamels Technology Handbook with Process and Formulations/ NIIR Board, 2016.
4. Tracton, Coatings Technology Handbook, 3rd Ed, CRC Press, 2005.

PTE5410 **Tyre Technology**

Tyre industry overview, development of tyre, raw materials for tyre aspects of tyre design, analysis of motive forces, types of bonding, set of service conditions, tyre size requirements, safety requirements manufacturing, classification of tyres, sizing & designation, tyre components, Tread design, role of foot print area and factors affecting tread life, various types of tread pattern, carcass design, role of

various fibres used in carcass, estimation of number of plies, bead design, various configurations of wires in bead assembly. Compound design, role of various mixing ingredients, various recipes, compound mixing, mixing equipments extrusion of components, tyre and wire cord manufacture, component preparation, green tyre building, pre- and post-curing operations/treatments. Tyre testing and evaluation, carcass strength, resistance to bead unseating, machine simulation tests, Indoor laboratory testing, field test on road, proving grounds, latest testing techniques. Problems associated with tyres and their remedies.

Suggested Books:

1. S.N. Chakravarty, Introduction to Tyre Technology, Polym Consultant, 2014.
2. De, Rubber Technologists Handbook vol 1, Rapra publishing, 2001.
3. A.N. Gent, J.D. Walter, The Pneumatic Tire, (Part I and Part II), National Highway Traffic Safety Administration, USA, 2005.

PTE5302 Minor Project

PTE5304 Packaging Technology

Introduction to packaging: history of packaging, classifications and functions of packaging, different classes of packaging materials, global and Indian packaging industry, active and passive packaging, modified atmosphere packaging, ancillary packaging materials. Paper Packaging: Classification and structural features of paper and paper board, thickness, size, class, basis weight, GSM and its measurement, technology of paper and paperboard manufacturing, types of paper packaging-labels, cushioning, sealing tapes, cap liners, processes of enhancing functional properties of paper packaging sizing, lamination, extrusion coating, varnishing and printing, advantages and disadvantages, molded paper packaging, emerging trends. Plastic packaging: Plastics used in packaging, technology of making thin films, theories of permeability,barrier properties of plastic films, WVTR, GTR and OTR-definition and experimental measurement, monolayer and multi-layer plastics films, flexible plastic packaging, breathing films. tetrapack- structure and materials used, sealing of plastic films, types of plastic packaging, food grade plastics, coating of anti-microbial substances, nanoCFTM, herbs and spices, food grade materials on films/packaging. Packaging testing, specifications and regulations, packaging standards- Indian and global, design of packaging- elements and principles of design a good packaging, sustainable packaging, biodegradable packaging materials, bioactive packaging, packaging for alcoholic beverages, single serve packaging, skin packaging. Thermoforming, packaging for medicine and electronics.

Suggested Books:

1. G.L. Robertson, Food Packaging: Principles and Practice, CRC Press, 2006.
2. R. Coles, D. McDowell and M. J. Kirwan, Food Packaging Technology, CRC Press, 2003.
3. R. Ahvenainen, Novel Food Packaging Techniques, Woodhead Publishing, 2003.

PTE5306 Biomedical Applications of Polymers

Natural polymers, synthetic polymers, biopolymers, biocompatibility of synthetic polymers. General Principles and properties of biomaterials, biofluids, cells, tissue and organs, Properties of implant polymers. Biomedical applications of water soluble polymers, Hard tissue prosthesis, bone prosthesis, bone cement, soft tissue prosthesis, hydrogels, contact and intraocular lenses, wound dressing and sutures, organ repair, tissue engineering, Polymer in drug delivery, gene therapy, synthetic gene

delivery to cell, applications of polymers in specific biomedical uses/devises like syringe, catheters, hemodialysis, hemofiltration, artificial muscles/ soft actuators, interface of polymers and biometrics, contraceptives based on polymers, Nano biomedical and molecular sensors. Biosensors like glucose biosensor/ cholesterol/ urea and DNA biosensor, transducer, bioprocess monitoring and control, nano devices for early detection of different diseases.

Suggested Books:

1. Abd-EL-Aziz, Biomedical Applications, Wiley-Blackwell, 2004.
2. Jenkin, Biomedical Polymers, CRC Press, 2007.
3. S. Buchel, Biopolymers for Medical & Pharmaceutical Applications Vol.I& II, CBS, 2005.

PTE5308 Polymers in Food & Healthcare Applications

Polymers in drug delivery: Monolithic delivery devices & polymer matrix. Controlled release (extended pulsatile, targeted), enhanced stability and bioavailability. Drug delivery based on biodegradable (lactide-co-glycolide) copolymer. Ion-exchange polymeric resin for medical use: Amberlite IRP69 in hyper leukemia, Cholestyramine resin (Duolite AP143) for cholesterol reduction and bile sequestering. The use of polymers in taste masking drug stabilizers, tablet disintegrating & sustained release. Biodegradable polymers & their role in drug delivery & biomedical applications. Polymeric Imaging agents. Polymeric contrast agents, for X-ray, MRI, Ultrasound contrast agents, Radio nucleotide imaging agents and optical imaging agents. Polymeric Implants. Key polymers like silicones, silicone elastomers, polyurethanes, polyethylene, PVC, fluoropolymers, PMMA, PHEMA, PNIPAM, natural polymers and biodegradable polyesters. Perspective & opportunities. Biomimetic polymers & their role in biological environment. Cationic polymers (PEI, PAMAM, Polylysine in gene delivery. Polysaccharide based polymers in tissue engineering & drug delivery. Use of PCL in resorbable drug delivery devices, bone tissue engineering, cartilage tissue engineering and gene delivery. Eco-friendly coatings and commercial polymeric coatings on food products: Processed food, fruits, confectionery, and nuts. Encapsulation of flavors, nutracueuticals and antibacterials. Edible coatings: Based on lipids, waxes & resins, polysaccharide based coatings, cellulose derivatives, starch derivatives, pectin's, Chitosan, carrageenans, gums of plant & microbial origins. Methods of coating & key to successful application and the properties like moisture & gas barrier, surface characteristics, sensory attributes, etc. Role of plasticizers, emulsifiers, antioxidant and anti-browning agents, application of nanoparticles and Nano composites. Regulatory aspects of polymeric coatings: As per FAO, Codex Alimentarius, WHO, USFDA, European Union, Japan, Australia and FSSAI India.

Suggested Books:

1. D.A. Tirrell & R. Langer, Polymers Science: A comprehensive Reference. Polymers in Biology and Medicine, Elsevier, 2012.
2. E.A. Baldwin, R. Hagenmaier and J. Bai, Edible Coatings and Films to improve Food Quality, CRC press, 2012.
3. F. Mohammad, Specialty Polymers, IK International Publisher, 2007.

PTE5202 Commercialization of Polymer & Chemical Technology Products

Why there is a need to commercialize polymer & chemical. Discovery, market needs development process, success rates and costs etc. Creating and marketing the image of polymer & chemical company. Art of negotiation & effective communication. Role of venture capitalism, business plan, selection of CEO and personnel, real estate for a business start-up. How to portray management and

role of a polymer & chemical manager, technology decision-making, and resource decision-making etc., Product marketing decision. Role of Research & development University-industry technology transfer arrangements, how and why a polymer & chemical company can benefit. Effective advertising and marketing. Opportunities international, marketing and lessons to be learned. Positioning, power and importance of positioning of a company name and product Workable marketing and the strength of distribution. Sources of new product ideas; general techniques, criteria for screening ideas; how to work with uncertainty, factors shaping future product and process development. Indian and foreign prospective of polymer, pharmaceutical & food industry, and current challenges. Case studies from polymer, pharmaceutical and food industries.

Suggested Books:

1. Rise, J. Trout, Positioning: The battle for your mind, Tata McGraw Hill, 2003.
2. G.P. Pisano, Science Business, Harvard Business Press, 2006.
3. G. Binder, P. Bashe, Science Lessons, Harvard Business, 2008.
4. C.R. Roth, From Alchemy to IPO, Basic Books, 2000.

PTE5204 Engineering Economics and Entrepreneurship

Relationship of Science, Engineering and Technology with economic development, Goods and utility, Cost Estimation: Factors affecting investment and production costs, Capital investments – fixed investments and working capital. Cost indices. Estimating equipment costs by scaling 6/10 factor rule. Methods for estimation capital investment. Cash flow statement, discounted cash flow, pay-back period, breakeven analysis, introduction to market survey, Balance sheet and income statement, minimum economics plant capacity, technological obsolescence, need for expansion and diversification, concept to marginal additional investment, role of research and development. Entrepreneurship, Market analysis, Knowledge of Achievement Motivation and Positive Psychology, Understanding of the basic aspects of Business Management. Concepts related to planning and efficiency, Concepts related to Risk Assessment, Legal aspects, regulatory aspects of SMEs and Launching Formalities, Market Survey, Overview of Indian and International Markets.

Suggested Books:

1. O.P. Khanna Industrial Engineering and Management, Dhanpat Rai Publication Pvt. Ltd., 2003.
2. Peters, Timmerhaus, Plant Design and Economics for Chemical Engineering, McGraw Hill, 1991.
3. R. Hisrich, M. Peters, D. Shepher Entrepreneurship, McGraw Hill, 2016.
4. G. Fairbrothers, T. Winter, From Idea to Success: The Dartmouth Entrepreneurial Network Guide for Start-Ups, McGraw Hill, 2011.

PTE5206 Statistical Quality Control

Concept of quality, quality characteristics, quality standards, quality cost, concept of quality control, quality control methodology, statistical methods of quality control, quality philosophy and management strategies. Population and sample, techniques of sampling, simple random sample, analysis of sample data, representation of sample data, practical examples, Population and sample distributions, estimation of population parameters, statistical hypothetical test, practical examples. Public awareness regarding hazards caused by indiscriminate use of plastics, proper disposal of plastics; Collection of recyclable plastics. Landfill, Incineration of plastics. Basis of control chart, types of control chart, design of control chart, analysis of control chart, control charts for variables

and attributes, case studies. Concept of process capability, measures of process capability, potential process capability, actual process capability, process capability analysis, case studies, Concept of six sigma, methods of six sigma, DMAIC methodology, DFSS methodology, six sigma control chart.

Suggested Readings:

1. G.A.V. Leaf, Practical Statistics for the Textile Industry-Part I & II, The Textile Institute, UK, 1987.
2. D.C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 2002.
3. B.S. Dhillon, Applied Reliability and Quality: Fundamentals, methods, and Procedures, Springer, 2007.

SEMESTER III

PTE6401 Rheology

Rheological properties of polymeric liquids basic concepts of fluid flow, Newtonian fluids, Non-Newtonian behavior of polymeric fluids and their reasons, Simple shear flow, Models describing the simple shear flows in non-Newtonian fluids, Generalized Newtonian models, Power law, Eyring model, Ellis model, Reiner Philipp off model, and Bingham Fluid model. Viscoelastic models, Mechanical Elements, Maxwell Model, Voigt Element, Maxwell-Wiechert Model, Voigt-Kelvin Model, Molecular theories, application of flexible chain models to solutions, The Zimm modification, extension to bulk polymer. Shear rheometer: sliding plates, falling ball rheometer, concentric cylinder rheometer, cone and plate rheometer, parallel disks, capillary rheometer, slit rheometer, oscillating disc rheometer, moving die rheometer and squeezing flow behavior. Mathematical modeling of rheometers, Viscoelastic behavior of polymeric fluids, elastic moduli, Boltzmann Superposition principle, relationship between the creep, compliance and the stress relaxation modulus. Time-Temperature Correspondence, Four region of viscoelastic behavior, time temperature superposition, the WLF equations transitions and relaxation in amorphous polymers, statistics of a polymer chain, rubber elasticity.

Suggested Books:

1. J.J. Aklonis, W.J. MacKnight, Introduction to Polymer Viscoelasticity, John Wiley and Sons, 1973.
2. R. B. Bird, O. Hassager, Dynamics of Polymeric Liquids; Volume 1, John Wiley and Sons, 1987.
3. A.Y. Malkin, A.I. Isayev Rheology: Concepts, Methods, and Applications, Chem Tec Publishing, 2006.
4. Bird, Stewart and N. Lightfoot, Transport phenomenon, John Wiley and Sons New York, 2002.

PTE6403 Polymer Product and Die Design

Basic design theory for product development, properties of plastic influencing design, simple structural load analysis and design aspects, wall thickness, tolerance, design limitations of plastic parts based on various processing techniques. Basic consideration of designing polymer products with rigid, flexible, static and dynamic loaded parts, Product design based on reinforced plastics. Mold Design, importance of mold & dies, mold types, molding cycle. General mold construction, use of local inserts, 2 & 3 plate molds, bolsters, ancillary items, guide pillars, guide bushed, positioning of guide pillars, sprues, gates and runners, ejector system, cooling systems, venting, degating devices, computer aided designs. Die design, Classification and construction of die, rectangular, ring, solid, profile dies, dies for multi-color or multi-material extrusion, cross head dies.

Suggested Books:

1. Rosato, Plastics Design Handbook, Springer, 2001.
2. Gordon, Industrial Design of Plastic Products, Wiley, 2002.
3. R.D. Beck, Plastic Product Design, Van Nostrand Reinhold, 1980.
4. Chitale & Gupta, Product Design & Manufacturing, Prentice Hall, 2007.

PTE6405 Additives and Compounding

Additives for processing: Heat stabilizer, plasticizer, lubricants, extender, processing aids, flow promoter, antistatic agents, nucleating agents, clarifiers. Additive for specific properties: Fillers and reinforcement, antiaging agents, colorants, flame retardants, blowing agents, antimicrobial agents. Compound development for end use, recipe formation, prediction of properties of product using compounded recipes, Introduction of mixing, blending, kneading, mixing mechanisms for solid, liquid and gases. Working principles of two roll mills, internal batch mixers, sigma mixers, high speed mixer, Impellers, process variables and product qualities of above machines, Trouble shooting of above machines. Extrusion: Qualitative and quantitative aspects of mechanism of screw extrusion and effects of screw speed and temperature on output and quality of extrudate, Twin screw extruder, type of twin screw extruder, Qualitative and quantitative aspects of mechanism of screw extrusion and effects of screw on output quality of compounds granulating equipment.

Suggested Books:

1. R.J. Crawford, Plastics Engineering, Butterworths, 2013.
2. Allen & Baker, Handbook of Plastic Technology, CBS Publications, 2004.
3. J.A. Brydson, Plastic Materials,Butterworth-Heinemann, 1999.

PTE6407 Extrusion and Injection Molding

Types of extruders: Single Screw, multi-screw, disk, ram, vented, hardware of extruder: extruder drive, thurst bearing, barrel, feed throat, extruder screw, die assembly, heating and cooling systems. Important polymer properties require for extrusion,: Bulk properties, melt flow properties, thermal properties, functional process analysis:basic screw geometry, solid conveying, plasticating, melt conveying, die forming, devolatization, mixing. Extruder Screw Design for various applications, Die design: basic consideration, film and sheet design, wire and cable dies, blown film dies, profile extrusion dies, coextrusion dies, trouble shooting extruder: machine related problems, polymer degradation, extrusion instabilities, air entrapment, gel problems, die flow problems. Injection molding machine-machine description study, types and limitations, working principles, constructional features, specifications, maintenance, types of clamping, temperature control, types of cylinder nozzles, ejection systems, starting and shutdown procedures, press capacity. hydraulics, basic principles, hydraulic systems as used in injection molding machine; process variables, shrinkage, warpage, defect free product, mold flow analysis – fundamentals of Fe analysis for fill, cool, warp, stress, doe, results interpretation. Mold design fundamentals, type of molds - two plate, three plate, feeding system – sprue, runner, gate design, ejection system - pin, sleeve, stripper plate, air ejection design. Moldings with undercuts – internal, external, threads, split cavity, split core designs. Advances in injection molding process- microcellular, gas assisted, water assisted, co-injection, insert, outsert, push-pull, multilive, vibration assisted, micro lamellar and lost core. designing with plastics, applications and future research.

Suggested Books:

1. Harper, Handbook of Plastic Processes, Wiley Interscience, 2006.
2. Tadmor & Gogos, Principles of Polymer Processing, Wiley Interscience, 2013.
3. R.J. Crawford, Plastics Engineering, Butterworths, 2013.

PTE6409 Nonwoven Technology

Concepts of nonwovens, elements of nonwovens, fibre geometry, structure of fibrous webs, basic nonwoven processes and their sequences. Staple-fibre based processes, fibre opening and mixing processes, staple fibre web formation processes, carding process, parallel-lay process, cross-lay process, perpendicular-lay process, air-lay process, wet-lay process. Web and Mechanical bonding processes, needle-punch and hydro entanglement process, principle and processes of thermal bonding, calendar, through-air, infra-red, ultrasonic and chemical bonding processes, chemical binders, methods of binder applications, saturation, foam, spray and print bonding process, methods of drying. Polymer-extrusion based technologies, spun bond technology, melt-blown technology, key process factors. Mechanical and chemical finishes and their method of applications.

Suggested Books:

1. Madhavamoorthy and Shetty, Nonwoven,Mahajan Publishers Pvt. Ltd., 2005.
2. S.J. Russell, Handbook of Nonwovens/ (Ed.) Woodhead Publishing, CRC Press, Washington DC, 2007.
3. Albrecht, Fuchs and Kettelmann, Nonwoven Fabrics: Raw Materials, Manufacture, Applications, Characteristics, Testing Process, Wiley-VCH, 2003.

PTE6301 Specialty Polymers

Electrically Conductive Polymers, photoconductive polymers, polymers in the conversion and storage of energy, polymeric liquid crystals, organic light emitting diodes (OEDs). Polymers with piezoelectric, pyroelectric and ferroelectric properties, polymers in lithographic processes, polymeric nuclear track detectors. Polymeric stabilizers, flame retardant polymers, corrosion inhibitor polymers, polymeric flocculating agents, antistatic polymers. Polymeric cement additives, polymers in oil production, polymeric dye carriers and polymeric surfactants, ionomers, IPN polymers. Polymer microgels, stimuli responsive polymers. Recent progress in specialty polymers.

Suggested Books:

1. R.W. Dyson Specialty Polymers, Blackie Academic & Professional, London, 1998.
2. B. Martin Functional Polymers, Plenum Press, New York, 1989.
3. Skotheim & Reynolds, Handbook of Conducting Polymers, CRC Press, 2007.

PTE6303 Applications of Nanomaterials in Polymers

Introduction to nanomaterials and nanocomposites, types of nanomaterials and their morphology. Preparation, structure, properties and of nanoreinforcing agents such as nanoclays, POSS, carbon nanostructures and nanoparticles. Effect of factors such as loading, dispersion and distribution, influence of size, shape and diameter of nanomaterials, functionalization of nanostructures. Structural and morphological characterization of nanocomposites and nanomaterials.Applications of polymeric nanocomposites: Polymeric nanoelectronics, molecular electronics components, concepts

of nanopolymer based switches and complex molecular devices; nanopolymers in medicines, nanomedicine etc.

Suggested Books

1. J. H. Koo, Polymer Nanocomposites, Mc Graw Hill, 2006.
2. S.N. Bhattacharya, Polymeric Nanocomposites- Theory and Practice, Hanser Gardner, 2008.
3. G.H. Michler and F.J. Baltra, Mechanical properties of Polymers based on Nanostructures and Morphpology, CRC Press, 2005.

PTE6305 Inorganic Polymers

Introduction, Types of inorganic polymers and their special characteristics. Characterization of inorganic polymers, Molecular weights, molecular weight distributions, chain statistics, solubility considerations, crystallinity, transitions, spectroscopy, mechanical properties. Polyphosphazenes: Synthesis, ring opening polymerization, mechanism, structure-property relationships; advanced elastomeric, fibers, and film forming, polyphosphazenes, polyphosphazenes as biomedical materials, organometallic polyphosphazenes, liquid crystalline and high refractive index polymers, polycarbophosphazenes and polythiophosphazenes. Polysilanes and related polymers: Introduction, synthesis and chemical modification of polysilanes, physical properties of polysilanes, electronic properties and conformations, photo-degradation of polysilanes, structure of polysilanes, technology of polysilanes. Miscellaneous inorganic polymers: Boranes, polymers containing sulfur and nitrogen – properties and applications, coordination conducting polymers

Suggested Books:

1. Mark, Allcock and West, Inorganic Polymers, Second Edition, Oxford, 2005.
2. Jaeger & Gleria, Inorganic Polymers, Nova Science Publisher, 2007.
3. Chandrasekhar, Inorganic and Organometallic Polymers, Springer, 2005.
4. Saxena, Inorganic Polymers, Discovery Publishing House, 2007.

PTE6307 Biosensors

Introduction to biosensors. Measurement and instrumentation principles. Fundamentals of transducers and sensors, their calibrations, selectivity, sensitivity, specificity, and transduction system analysis. Transduction principles used in biosensors i.e. electrochemical transducers (amperometric, potentiometric, conductometric), optical transducers (absorption, fluorescence, SPR), thermal transducers, piezoelectric transducers and transducers related technology. Bio-recognition systems based on enzymes, oligonucleotides and nucleic acids, antigen-antibody, and molecularly imprinted polymer. Immobilization of biomolecules. Limitations & problems. Methods for biosensors fabrication based on self-assembled monolayers, screen printing, photolithography, micro-contact printing, etc. Nanomaterial-based biosensors. Microfluidic devices for Lab-on-a-chip. Engineering concepts for mass production. Application of biosensor technologies in clinical diagnostics, defense industries environmental monitoring, food/water quality control, forensic science. Selected examples and future developments.

Suggested Books:

1. B. Florinel-Gabriel, Chemical Sensors and Biosensors: Fundamentals and Applications, John Wiley & Sons, 2012.
2. U. Bilitewski, A.P.F., Turner Biosensors for Environmental Monitoring, Academic Publishers, 2000.
3. F.S. Ligler, C.A. Rowe, Optical Biosensors: Present & Future, Elsevier, 2002.
4. C.M. Pandey, B.D. Malhotra, Biosensors: Fundamental and Applications (2nd Edition), De Gruyter, 2019.

PTE6201 Practical Training in Industry

The evaluation will be based on industrial training/research exploration carried out during summer break after 2nd semester with respect to relevance of work, presentation and report writing.

PTE6203 Research Exploration

Research Papers

PTE6205 Special Lectures in Polymers and Industrial Visits

Research paper, summary of industrial visits and special lectures

Semester IV

PTE652 Research Project

PTE602 Major Project II

DEPARTMENT OF APPLIED PHYSICS

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Nano Science and Technology)

Programme Specific Outcomes

1. To provide an opportunity to the students to explore size-dependent properties of materials leading to the modern day science and technology.
2. The students will attain successful professional careers by applying engineering skills for making nanoscale smart materials and devices to meet the challenges in industry and academia to become entrepreneurs.
3. The students will engage in lifelong learning to adapt the future technologies in the field of nanoscience.
4. To prepare the students to take-up career in different industries or to pursue higher studies and multidisciplinary research.
5. Graduates will practice professional ethics, communicate effectively, emerge as leaders in chosen fields and be socially reponsible.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN NANO SCIENCE AND TECHNOLOGY (NST)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	NST501	Physics of Nanomaterials	Core	4	3	0	2	15	25	20	40	-	17
	2	NST503	Chemistry of Nanomaterials	Core	4	3	0	2	15	25	20	40	-	
Group B	3	NST5401/5403/.....	Elective 1	Elective	4	4	0	0	20	0	30	50	-	
	4	NST5301/5303/.....	Elective 2	Elective	3	3	0	0	20	0	30	50	-	
	5	NST5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	NST502	Analytical Techniques	Core	4	3	0	2	15	25	20	40	-	17
	2	NST504	Design and Synthesis of Nanostructures	Core	4	3	0	2	15	25	20	40	-	
Group D	3	NST5402/5404/.....	Elective 4	Elective	4	4	0	0	20	0	30	50	-	
	4	NST5302/5304/.....	Elective 5	Elective	3	3	0	0	20	0	30	50	-	
	5	NST5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	NST651	Research Project	Core	12						0	100		
	Track 2													
	1	NST601	Major Project I	Core	3						40	60		
	2	NST6401/6403/.....	Elective 7	Elective	4	4	0	0	20	0	30	50	-	
	3	NST6301/6303/.....	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	NST6201/6203/.....	Elective 9	Elective	2	2	0	0	20	0	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group F	1	NST652	Research Project	Core	12						0	100		
	Track 2													
	1	NST602	Major Project II	Core	12						0	100		

LIST OF ELECTIVES :														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	NST5401	Computational Physics and Programming	Elective	4	4	0	0	20	0	30	50	-
	2	NST5403	Nanoscale Modeling and Simulation		4	4	0	0	20	0	30	50	-
	3	NST5405	Environmental Nanotechnology		4	4	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	NST5301	Thin Film Technology	Elective	3	3	0	0	20	0	30	50	-
	2	NST5303	Functional Materials and Devices		3	3	0	0	20	0	30	50	-
	3	NST5305	Material Science at Nanoscale		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	NST5201	Seminar	Elective	2	0	0	2	-	0	-	100	-
	2	NST5203	Research Methodology		2	2	0	0	20	0	30	50	-
	3	NST5205	Micro Economics		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	NST5402	Nanophotonics	Elective	4	4	0	0	20	0	30	50	-
	2	NST5404	Spectroscopic Techniques for Nanomaterials		4	4	0	0	20	0	30	50	-
	3	NST5406	Molecular Spectroscopy		4	4	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	NST5302	Minor project	Elective	3	0	0	-	-	40	-	-	60
	2	NST5304	Renewable Energy Technology		3	3	0	0	20	0	30	50	-
	3	NST5306	Structural Analysis of Nanomaterials		3	3	0	0	20	0	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	NST5202	Nano-Electronics and Devices	Elective	2	2	0	0	20	0	30	50	-
	2	NST5204	Nanocomposites		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	NST6401	Nanobiotechnology	Elective	4	4	0	0	20	0	30	50	-
	2	NST6403	Nanosensors and Devices		4	4	0	0	20	0	30	50	-
	3	NST6405	Microelectromechanical Systems (MEMS)		4	4	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	NST6301	Nanolithography and Device Fabrication	Elective	3	3	0	0	20	0	30	50	-
	2	NST6303	Plasma Technology		3	3	0	0	20	0	30	50	-
	3	NST6305	Nanotechnology for Medical Diagnostic and Therapy		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	NST6201	Spintronic	Elective	2	2	0	0	20	0	30	50	-
	2	NST6203	Biophotonics		2	2	0	0	20	0	30	50	-

SEMESTER I

Courses

NST501 Physics of Nanomaterials

Introduction to the nanoscience, nanotechnology and significance of nanoscale, surface area and quantum confinement, different type of nanomaterials. An overview of quantum mechanical concepts related to low–dimensional systems- Wave-particle, de Broglie wavelength, time- dependent and time independent Schrodinger equation, Particle in box.

Excitons classification of quantum confined systems, Density of electronic states, Local density of states, Excitons in molecular crystals and in nanostructures, Direct and indirect band gap semiconductors; Lattice matching, Effective mass, Heterojunctions, Type I and Type II hetero structures. Optical properties of nanomaterials and Photoconductivity. Crystal structure, crystallographic planes, Miller indices, Bragg's law and X-ray Diffraction.

Statistical Mechanics, Microcanonical, canonical- and grand canonical ensembles and their connections, Classical Statistical systems, Boltzmann statistics and quantum statistical systems, Fermi-Dirac and Bose-Einstein Statistics and their applications.

Suggested Books:

[1] T. Pradeep, Nano: The essentials, Tata Mc Graw Hills, 2007.

[2] B.G. Streetman and Banerjee, Solid State Electronic Devices, Prentice Hall of India, 2001.

[3] G.L. Hornyak, J. Dutta, H.F. Tibbals and A. Rao, Introduction to Nanoscience, CRC Press, 2008.

[4] C.P. Poole, Jr. and F.J. Owens, Introduction to Nanotechnology, Wiley-Interscience, New York, 2003.

NST503 Chemistry of Nanomaterials

Chemical Bonding: Bonding Forces and Energies- Types of bonding- Ionic, Covalent, Metallic, van der Waals, π- π-stacking, Hydrogen bonding. Surface adsorption, Freudlich and Langmiur Adsorption Isotherm, Gibb's Isotherm, Their fundamental approach to Nanomaterials. Colloidal chemistry: Colloidal properties, origin of charge on colloidal properties. Determination of colloidal particle size. Synthesis of Nano materials/Nano systems employing chemical, precipitation, coprecipitation, microemulsion, thermolysis, Electrochemical and photochemical methods.

Nano polymers/Nanocomposites: Synthesis, Characterization, Properties and applications of Nano polymers/Nanocomposites, Polymers, metal oxide glass and ceramic-based nano composites and their use in catalysis. Preparation and Stabalization of Metal/Alloy nanoparticles. Separation and purification of Nano particles by Membrane Technology: Ion Exchange Membranes, Electrodialysis, Reverse Osmosis, Ultrafiltration Microfiltration and Nanofiltration Techniques.

Suggested Books:

[1] P.M. Ajayan and L.S. Schodler, Nanocomposites Science and Technology, Wiley, New York, 2003.

[2] C. N. R. Rao, Chemistry of Nanomaterials: Synthesis properties and applications, Wiley, New York, 2004.

[3] G. A. Ozin and A. C. Arsenault, Nanochemistry: A chemical approach to nanomaterials, Royal Society of Chemistry, Cambridge U.K., 2005

[4] K Holmberg, B jonsson and B Kromberg, Surfactants and Polymers In Aqueous, Wiley England,2004

[5] C. Brechignac, P. Houdy and M. Lahmani, Nanomaterials and Nanochemistry, Springer publication, 2007.

NST5401 Computational Physics and Programming

Roots of equations, Direct method and iteration method, Bisection method, Regula Falsi Method or Method of False position, Secant method, Newton-Raphson method, Finite differences, InterpolPation with equally spaced data points: Newton's forward and backward formulae for interpolation, Central difference: Gauss forward, Gauss Backward, Stirling, Bessels, Everett's formula for interpolation, Interpolation with unequally data points: Lagrange's interpolation formula, Divided differences and their property, Newton Divided differences formula.

Numerical integration, Newton-cotes integration formulae, trapezoidal method, Simpson's 1/3-rule, Simpson's 3/8-rule, Boole's and Weddle's Rule, Romberg integration, , Euler-Maclaurin formula, Numerical double integration, Numerical solution of ordinary differential equations by Taylor's series, Picard's method of successive approximation methods, Euler's method, modified Euler's method, Runge-Kutta method, solution of second order and simultaneous differential equations

Introduction to Matlab, Array & matrix operation, basic plotting's, loops and controlled loops, arithmetic, relational & logical operators, script and function files, inbuilt function for numerical methods: root findings, interpolation, curve fitting, integration, differentiation and solution of first and second order differential equations.

Suggested Books:

[1] S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw-Hill International Editions, 1998.

[2] T. Pang, An Introduction to Computational Physics, Cambridge University Press, 2010.

[3] A. Gilat, Numerical Methods for Engineers and Scientists, John Wiley & Sons, 2008.

[4] C. F. Gerald and P. O. Wheatle, Applied Numerical Analysis, Pearson, 2003.

[5] S. C. Chapra, MATLAB Programming for Engineers, Cengage, 2012.

NST5403 Nanoscale Modeling and Simulation

Introduction to the modeling in materials science; Simulation vs. modelling; Simulation techniques for nano, micro, meso and continuum scales; Nanoscale and microscale – molecular dynamics and Monte Carlo techniques.

Microstate, Macrostate, Distribution Laws, Indistinguishable particles, statistical mechanics and thermodynamics laws; Maxwell Botzmann statistics.

Monte Caro Simulation: Principles of equilibrium; Monte Carlo simulation-estimator; Importance of sampling, acceptance ratio, continuous time MC, Ising model and Metropolis algorithm; Simulation of Interfaces; Analysis of MC data; Out of equilibrium simulation; MC simulation in surface science; Implementation of MC algorithms.

Molecular Dynamics: Introduction, Interatomic potentials, Equations of motion, integration, Pair Distribution, constraints and free energy; Time correlation functions and spherical densities;

Velocity autocorrelation functions; Time correlation function and relaxation times; Applications in nanomaterials.

Overview of Modelling, Simulation and Visualization Software -Gaussian, Comsol Multiphysics and Octave.

Suggested Books:

[1] M.E.J. Newman, and, G.T. Barkema, Monte Carlo Methods in Statistical Physics, Oxford University Press, 1999.

[2] J. G. Lee, Computational Materials Science: An Introduction, CRC Press, 2016.

[3] M.M. Wolfson, and G. J. Pert, An Introduction to Computer Simulation, Oxford Press, 1999.

[4] D. Raabe, Computational Materials Science: The Simulation of Materials Microstructures and Properties, Wiley-VCH, 1998.

[5] D.P. Landau and K. Binder, A Guide to Monte Carlo Simulation in Statistical Physics, Cambridge University Press, 2005.

NST5405 Environmental Nanotechnology

Overview of physical, chemical and biological processes concerning the environment; types, transport and transformation processes of contaminants in air, water and soil; effects of contaminants on environment. Environmental impacts of nanomaterials - Exposure and risk assessment, Dose-response, mechanisms of toxicity; ecotoxicological impacts of nanomaterials - bioavailability and uptake; assessment of life cycle risk of nanomaterials.

Nanoparticle transport, aggregation and deposition – physicochemical interaction, aggregation, eposition, nanoparticle behavior in heterogeneous systems, airborne nanoparticles. Reactive oxygen species (ROS) generation – semiconductor nanoparticles and ROS generation, metal sulphide surface chemistry and free radical generation, fullerene photochemistry and ROS generation potential, Environmental applications of nanomaterials.

Analytical methodologies for studying impact of nanomaterials in environment – atomic absorption spectrometry, inductively coupled plasma spectrometry, chromatography, thermal methods, hyphenated techniques.

Suggested Books:

[1] M.R. Wiesner and J.Y. Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill, New York, 2007.

[2] M. Diallo, J. Duncan, N. Savage, A. Street and R. Sustich, Nanotechnology Applications for Clean Water, William Andrew, 2008.

[3] J. R. Lead, and E. Smith, Environmental and Human Health Impacts of Nanotechnology, John Wiley & Sons, 2009.

[4] D.A. Skoog, F.J. Holler and S.R. Crouch, Instrumental Analysis, Cengage Learning India Private Limited, New Delhi, 2006.

[5] G.M. Masters, and W.P. Ela, Introduction to Environmental Engineering and Science, Pearson, 2007.

NST5301 Thin Film Technology

Introduction to the thin film deposition techniques – Kinetic theory of gases – Physical vapour deposition techniques – Physics and Chemistry of Evaporation – Thermal evaporation – Pulsed laser deposition – Molecular beam epitaxy – Sputtering deposition, Chemical methods – Thermal Chemical Vapour Deposition – Plasma enhanced Chemical Vapour Deposition – Spray Pyrolysis – Sol Gel method – Spin and Dip coating – Electrophoretic and electrochemical deposition. Self – assembled monolayers.

Nucleation, growth and epitaxy: Substrate surface, Adsorption, Surface energy, film growth modes, nucleation model, manifestation of epitaxy, lattice misfit and defect formation, morphology, grain growth, texture, microstructural control.

Fundamentals of diffusion –Grain Boundary Diffusion, metal-semiconductor reactions, film growth modes, Transformations-Origin of Thin film stress – Classifications of stress – Stress in epitaxial films – Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature.

Suggested Books:

[1] R. F. Bunshah, Hand Book of Deposition technologies for Thin Films and coatings Second Edition, Noyes Publications, 1994.

[2] M. Ohring, Materials Science of Thin Films, Academics Press Limited, 1991.

[3] H. Luth, Solid surfaces, Interfaces and Thin Films 4th edition, Springer Publishers, 2010.

[4] H. Ibach, Physics of surfaces and Interfaces, Springer Publishers, 2006.

[5] K.L. Chopra, Thin Film Phenomena, Mc Graw-Hill Book, 1969.

NST5303 Functional Materials and Devices

Concept of functional materials. Challenges in the science and technology of advanced materials, Classification of materials, bonding in materials. Characterization of materials. Structural, morphological, optical, electrical, magnetic, dielectric, physical and thermal properties of materials and other various properties of materials.

Symmetry analysis of solids and the Landau theory of phase transitions; piezoelectric sensors, actuators and transducers; ferromagnetic and ferroelectric memories and flexoelectricity; phase change memories; liquid crystal displays; skyrmions and vortex structures. Electro and magnetocaloric cooling; epitaxial engineering of heterointerface properties and domain wall properties; mixed ionic and electronic conductivity, memristive memories, artificial synapses and neuromorphic circuitry.

Potential applications of selected functional materials from various areas of inorganic, organic and hybrid materials, Process and materials optimization, Optoelectronic materials and devices, Enhancement of device performance, Recent trends in Functional materials and devices and Future perspectives of advanced functional materials.

Suggested Books:

[1] W. D. Callister and Jr., Fundamentals of Materials Science and Engineering, John Wiley & Sons, 2012.

[2] B.D. Cullity, Elements of X-Ray diffraction, Addison Wesley, 1956.

[3] G. Sridhar, S. G. Choudhary and N. G. Goswami, Materials characterization techniques, NML, Jamshedpur.

[4] A.K. Tyagi and S. Banerjee, Functional materials: preparation, processing and applications, Elsevier, 2011.

[5] B. Sanyal and O. Eriksson, Advanced functional materials: a perspective from theory and experiment, Elsevier, 2012.

NST5305 Material Science at Nanoscale

Single crystalline, polycrystalline and amorphous structures, classification of crystals, imperfection in solids, grain boundaries and its effect on mechanical properties, Phase transitions in nanosystems-comparison to large systems. Carbon molecules, nature of carbon bonds, new carbon structures, Buckyballs, Carbon Nanotubes-fabrication, structure, electrical and mechanical properties. Applications in field emission, shielding, computers, fuel cells, sensors, catalysis, mechanical reinforcement

Bulk nanostructured materials, synthesis, mechanical and electrical properties, metal nanocluster composite glasses, porous silicon, natural nanocrystals, nanoparticles in zeolites, crystals of metal naoparticles, nanoparticle lattices in suspensions, photonic crystals, nanocopmposites, nanoceramics, ceramic matrix composites. Nanostructured ferromagnetism, effect of nanostructuring, nanomagnets, nano carbon ferromagnets, giant and colossal magnetoresistance, Ferro fluids, Nanocmposites of dielectric, piezoelectric and ferroelectric materials. Polarization types, frequency dependence, other relevant current topics.

Fundamental Magnetic Properties; Nanocomposite soft magnetic materials, hard magnetic materials; Effects of particle size and Surface chemistry on magnetic properties.

Suggested Books:

[1] C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 2012.

[2] N. W. Aschroft and N. D. Mermin, Solid State Physics, Holt, Rinehart and Winston, 1976.

[3] P. M. Ajayan, L. S. Schadler and P. V. Braun, Nanocomposite: Science and Technology, Wiley, 2003.

[4] G. A. Mansoori, Principles of Nanotechnology, World Scientific, 2005.

[5] M. F. Ashby, Nanomaterials, Nano-tech & Design by, Butterworth-Heinemann, 2009.

NST5201 Seminar

NST5203 Research Methodology

Knowledge of research methods- The role of research in academia/industry- needs of research-understanding the modern research methods and its trends/goals- critical thinking and its evaluation parameters-developing and designing questionnaires- implementations– challenges /obstacles.

Identifying the key resources: - Online/offline data, database search tools/algorithms, accessing the review articles, theses/dissertations, catalogs, citations– evaluation of quality Impact factor (QIF) of such resources– modeling using para- and meta-analysis– parenting the records and documentation/ compilation.

Motivational research– Types of research: - Descriptive vs. Analytical, Applied Vs Fundamental,

Qualitative Vs Quantitative, Conceptual Vs Empirical: laboratory/simulation research, clinical/ diagnostic research, historical/contemporary research,

Types of research techniques: - library research, field research, laboratory/simulation research– Research Process: - Extensive literature survey, Formulating the research problem, development of working hypotheses, preparing the research design, determining the sample design– Art of scientific writing. Brief overview of ethics and science.

Suggested Books:

[1] A. Briggle and C. Mitcham, Ethics and Science: An introduction, Cambridge University press, 2012.

[2] G. Comstock, Research Ethics: A philosophical guide to the responsible conduct of Research, Cambridge University Press, 2013.

[3] A. Lahthorp and K. Foss, Student cheating and plagiarism in the internet era: A wake up call, Greenwood publishing group Inc, 2000.

[4] E. B. Wilson, An introduction to scientific research, Dover publication, 1990.

[5] A. Robert, Day and B. Gastel, How to write and publish a scientific paper, Cambridge University press, 2012.

NST5205 Micro Economics

Theory of consumer behavior- Law of demand and supply, elasticity, Budget constraint, concept of utility, diminishing marginal utility, Diamond-water paradox, income and substitution effects; indifference curves.

Theory of cost and production - Production: behavior of profit maximizing firms, production process, production functions, law of variable proportions, isoquant and isocost lines, cost minimizing equilibrium condition. Costs: costs in the short run, costs in the long run, revenue and profit maximizations, minimizing losses, short run industry supply curve, economies and diseconomies of scale.

Theory of firms and market structure- Equilibrium in short run and long run under-Perfect competition, Monopoly and Imperfect Competition: Monopolistic competition, oligopoly.

Suggested Books:

[1] K. E. Case and R. C. Fair, Principles of Economics, Pearson Education, 2007.

[2] A. Koutsoyiannis, Modern Microeconomics, Palgrave Macmillan, 2003.

[3] J.M. Henderson and R. E. Quandt, Microeconomic Theory: A Mathematical Approach, McGraw-Hill, New York, 1958.

SEMESTER II

Courses

NST502 Analytical Techniques

X-Ray diffraction. Dynamic light scattering, Light microscopy, Scanning Electron Microscopy based techniques (Secondary electron imaging, backscattered electron imaging, Electron backscattered diffraction (EBSD). TEM based techniques (diffraction contrast imaging, Electron diffraction, High

resolution imaging). Scanning probe microscopies (Atomic Force Microscopy (AFM), Piezeo Force Microscopy, Scanning Tunneling Microscopy).

Ultraviolet-visible-infrared, Fourier Transform Infrared Spectroscopy. Raman. X-ray photoelectron spectroscopy. Auger spectroscopy. Energy Dispersive X-ray Spectroscopy, Wavelength Dispersive X-ray Spectroscopy, Electron Energy Loss Spectroscopy, scanning tunneling spectroscopy. Differential Thermal analysis (DTA) - Differential Scanning Calorimetry (DSC) – Thermo-gravimetric analysis (TGA). Electrical measurement techniques: Resistivity, Polarization, Dielectric properties, electrochemical techniques (Cyclic voltametry). Magneto-Resistance, Vibrating Sample Magnetometer, Superconducting Quantum Interference Device, Magneto Optical Kerr Effect.

Suggested Books:

[1] C. N. R. Rao, A. Mueller and A. K. Cheetham, Chemistry of nanomaterials: Synthesis, properties and applications, Wiley, 2004.

[2] C.N.R. Rao, P. J. Thomas and G. U. Kulkarni, Nanocrystals: Synthesis, properties and applications, Springer, 2007.

[3] B. D. Cullity and R. W. Stock, Elements of X-Ray Diffraction, Pearson, 2014.

[4] P. J. Goodhew, J. Humphreys and R. Beanland, Electron Microscopy and Analysis, Taylor & Francis, 2000.

[5] D. B. Williams and C. B. Carter, Transmission Electron Microscopy: A Textbook for Materials Science, Springer, 2009.

NST504 Design and Synthesis of Nanostructures

Physical Methods: Growth and properties of nanostructures using top-down and bottom-up approaches and their applications. Self-assembly and self-organization, formation of nanostructure by mechanical milling (Ball milling). Overview of thin film technology for various nanotechnology applications, Miniaturization of electrical and electronic devices. Arc discharge, Ion sputtering, Laser ablation, pulsed laser deposition (PLD), Laser pyrolysis, Molecular beam epitaxy, Chemical vapour deposition method and other variants, electrodeposition. Microwave synthesis of NPs.

Chemical Methods: Sol-gel techniques, Colloidal particle synthesis. Synthesis of nanocomposites and nanostructures, fabrication of quantum dots, nanowires, nanorods Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sono-chemical routes, Hybrid methods, Solvated metal atom dispersion, Micelles and microemulsions.

Biological Methods: Synthesis process and application of Biological Methods. Electro-spinning synthesis of nanofibers, Microfluidic Synthesis of NPs, Green Synthesis of NPs using plants/bacteria/ fungi.; Biological material based metallic nanowires.

Suggested Books:

[1] C. P. Poole, Jr. and F. J. Qwens, Introduction to Nanotechnology, Wiley, 2003.

[2] C. N. R. Rao, A. Mueller and A. K. Cheetham, Chemistry of nanomaterials: Synthesis, properties and applications, Wiley, 2004.

[3] J. Arbiol and Q. Xiong, Semiconductor Nanowires: Materials, Synthesis, Characterization and Applications, Woodhead Publishing, 2015.

[4] A. Alves and C. P. Bergmann, Novel Synthesis and Characterization of Nanostructured Materials, Springer Berlin Heidelberg, 2013.

[5] W.A. Goddard III and Donald Brenner Handbook of Nanoscience, Engineering, and Technology, CRC Press, 2002.

NST5402 Nanophotonics

Photons and electrons- similarities and differences, confinement of photons and electrons, Nanoscale optical interactions-axial and lateral nanoscopic localization, quantum confinement effects, cooperative transitions and emission.

Introduction to photonics, Electromagnetic properties of nanostructures–Wavelength and Dispersion laws, Maxwell and Helmholtz equations, Photonic band-structure and photonic band gap, Propagation of light in periodic media. Band structure in periodic media– 1D and 2D cases. Fabrication of photonic crystals: Photonic crystals by self-assembly - Photonic Crystals by Microfabrication, Photonic Crystals with Tunable Properties. Photonic crystal fibers, optical communication and sensors.

Harmonic generation in photonic nanostructures: Metal nanoparticles, Nanoparticles in monolayer–planar photonics structures- photonic crystals.

Suggested Books:

[1] P. N. Prasad, Nanophotonics, Wiley-Interscience, 2004.

[2] M. Ventra, S. Evoy and J. R. Heflin, Introduction to Nanoscale Science & Technolog, Springer, 2004.

[3] K. Sakoda, Optical properties of photonic crystals, Springer, 2004.

[4] R. H. Kingston and D.L. Mac Adam, Detection of optical and infrared radiation, Springer, 1978.

[5] C. P. Poole, Jr. and F. J. Qwens, Introduction to Nanotechnology, Wiley, 2003.

NST5404 Spectroscopic Techniques for Nanomaterials

Basic concepts-Spontaneous Emission- Classical Bound- Radiating Electron-Quantum Mechanical Radiative Decay-Absorption and Emission - Absorption Coefficient and Absorption Cross-Section, Absorption and Induced Emission-Nano-optics and local spectroscopy, Fluorescence spectroscopy -Scanning plasmon near-field optical spectroscopy (SPNM)-near-field optical spectroscopy- nearfield nonlinear optics.

Simplified model for vibrational interactions-Characteristic bands for organic compounds- Attenuated-total reflection (ATR) and grazing incidence angle techniques-Reflection-absorption IR spectroscopy (RAIRS)-The Raman Effect- Lateral and in-depth Resolution of Conventional μRS- Resonant Raman Spectroscopy (RRS)- Nano-specific Modes- Surface-Enhanced Raman Spectroscopy (SERS)- Nano-Raman- Phase Identification and Phase Transitions in Nanoparticles- Characterizing Carbon Materials with Raman Spectroscopy.

Absorption saturation and harmonic generation, Second-harmonic generation (SHG) and sum frequency spectroscopy (SFG) - Luminescence up conversion. Optical properties of assembled nanostructures-interaction between nanoparticles-Direct and indirect gap transitions-, -Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and chemiluminescence - X-ray fluorescence spectrometry-

X-Ray Beam Effects, Spectral Analysis -Core Level Splitting Linewidths- Elemental Analysis: Qualitative and Quantitative -Secondary Structure, XPS Imaging -Angle-Resolved.

Suggested Books:

[1] G. B. Vladimir and H. G. Rubahn, Optics and Spectroscopy at Surfaces and Interfaces, John-Wiley and Sons, 2005.

[2] W. William and Parson, "Modern Optical Spectroscopy", Springer, 2007.

[3] R. Joseph and Lakowicz, Principles of fluorescence spectroscopy, Springer, 2010.

[4] J. J. Jhang, Optical properties and spectroscopies of Nanomaterials, World Scientific Publishing, 2009.

[5] J.R. Lakowicz, Principles of fluorescence spectroscopy, springer, 1983.

NST5406 Molecular Spectroscopy

Overview of Bohr-Somerfield theory of Hydrogen Atom, Quantum mechanics of Hydrogen atom: Angular momentum & Parity, Magnetic dipole moments, Electron spin and Vector atom model, Spin orbit Interaction. The Zeeman Effect, Paschen-Back effect, The Stark effect, Hyperfine structure of spectral lines.

Rotational spectroscopy: Rigid rotor, Rotational spectra of diatomic molecules, Intensities of spectral lines, Isotope effects, Non-Rigid Rotator, Rotation levels of polyatomic molecules: spherical, symmetric, and Asymmetric top molecules. Vibrational spectroscopy: Vibration of diatomic molecules, Harmonic oscillator and Anharmonic oscillator, Vibrational-rotational couplings, Vibration of polyatomic molecules.

Electronic spectroscopy: Electronic spectra of diatomic molecules, vibrational coarse structure, Franck-Condon Principle, Dissociation energy and dissociation products, Rotational fine structure of Electronic-Vibration transition, Production of excited state, Radiative processes, Kasha's Rule, Jablonbski diagram, Luminescence, Photoluminescence, kinetics, Quantum yield and Lifetime.

Suggested Books:

[1] H. E. White, Introduction to Atomic Spectra, McGraw Hill, 1934.

[2] R. B. Leighton, Principles of Modern Physics, McGraw Hill, 1959.

[3] G. Herzberg, Molecular spectra and molecular structure I, II and III. Spectra of diatomic molecules, Prentice-Hall, 1939.

[4] C. N. Banwell and E. M. McCash, Fundamentals of molecular spectroscopy, McGraw Hill, 1994.

[5] J.R. Lakowicz, Principles of fluorescence spectroscopy, springer, 1983.

NST5302 Minor Project

NST5304 Renewable Energy Technology

Energy challenges, development and implementation of renewable energy technologies-nanotechnology enabled renewable energy technologies -Energy transport, conversion and storage-Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.

PV modules: Module and Circuit Design - Identical and Non-Identical Cells– Module Structuring and assembly - Environmental Protection - Thermal Considerations – Electrical Considerations and output conditioning - assembly materials– interconnects– crystalline and thin film modules - issues with solar PV modules, bypass diode and blocking diode– module testing and analysis.

Nanomaterials in Energy Storage Devices: multiwall carbon nanotubes for Li-Ion Batteries, Nanomaterials in Electrodes, Hybrid Nanotubes: Anode Material, Supercapacitor, Battery Electrodes.

Energy from waste- Bio-chemical Conversion: Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion biogas production, landfill gas generation and utilization, present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages. Device isolation & analysis.

Suggested Books:

[1] J. Twidell. and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, 1986.

[2] H. J. Moller, Semiconductor for solar cells, Artech House Inc, 1993.

[3] D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor & Francis, 1998

[4] K L Chopra, Suhit Ranjan Das, Thin Film Solar Cells, Springer Science, 1983.

[5] D. Linden and T. B. Reddy, Handbook of batteries 3rd Edition, Mcgraw Hill, 2002.

NST5306 Structural Analysis of Nanomaterials

Phase, Phase rules of Gibbs; Phase diagram: unary, and ternary systems, lever rule; microstructure during cooling, Crystal formation (energy vs. distance between atoms); Structural Magic number rule to show the number of atoms in nanoparticles; X-ray diffraction by the crystalline phase. Basic principles; Hanawalt method; Examples of phase analysis single phase and phase mixture; Analysis of unknown phase mixtures; practical difficulties. Quantitative Analysis: Atom fraction and weight fraction; Factors that control absolute and relative x-ray intensities. Single Phase-chemical analysis by parameter measurement, principle and application of this method. Multiphase: Basic principles, Methods like external standard method; Direct comparison method and internal standard method; precautions for precise measurements; Practical difficulties.

Need for orientation identification, methods for determining crystal orientation; Laue method (the back- reflection and the Transmission Laue method). The diffractometer method; Zone, pole and trace, Stereographic projection, Wulff net, Angle between poles and traces, rotation of the poles around axes, Stereographic projection diffraction spots of transmission Laue methods, Greninger chart for the orientation of back- reflection Laue patterns, Stress Measurement.

Suggested Books:

[1] B. D. Cullity, S. R. Stock, Elements of X-Ray diffraction, Prentice Hall, 3rd Edition, New Jersey, 2001.

[2] R. Phillips, Crystal defects and Microstructures, Cambridge University Press, Cambridge, U.K., 2001.

[3] Z. L. Wang, Characterization of Nanophase Materials, Wiley-VCH, Weinheim, Germany, 2000.

[4] M. D. Graef and M. E. McHenry, An Introduction to crystallography, diffraction and symmetry, Cambridge University Press U.K., 2007.

[5] S. M. Allen and E. L. Thomas, The structure of Materials (MIT Series in materials science and engineering), John Wiley & Sons, US, 1999.

NST5202 Nano-Electronics and Devices

Enhancement mode & Depletion mode MOSFETs, Drain current and Transfer Characteristics Analysis-Linear Regime, and Saturation Regime, Parameter Evaluation: Transconductance, Drain Conductance, Cut-off Frequency, Pass Transistors, Pull-up and Pull Down Transistor. Alternative forms of Pull-Up. Basic MOS inverter design, transfer characteristics, logic threshold, NAND\ NOR logic implementation based on MOSFETs, Transit time and inverter time delay, CMOS inverter. Inverting and non-inverting type super buffers, noise margins.

MOS design rules: Lambda based design rules and MOS layers. Stick diagrams, NMOS and CMOS design layout diagrams, Scaling of MOS Circuits. Functional limitations to scaling. Tunneling Diode and Resonating tunneling diodes: Structure and operation. Concept of double quantum well and its role in the Resonance Tunneling Diodes; Single electron tunneling Transistor; Current versus energy characteristics of SET; Derivation of the resistance offered by SET for electron tunneling. Applications of SET. Solar Cells: Thin Film Solar Cells, Multi-junction Solar Cells and Pervoskite Solar Cells; Basics of Direct and Indirect Semiconductors w.r.t. Light Emitting Diodes (LEDs); Types of LEDs and Materials for LED Fabrication.

Suggested Books:

[1] N. H. E. Weste, Principles of CMOS VLSI Design (2nd edition), Addison Wesley, 1994.

[2] D. A. Pucknell and K. Eshraghian, Basic VLSI Systems and Circuits, Prentice Hall, 1995

[3] W. C. Lin, Handbook of Digital System Design, CRC Press, 1990.

[4] S. M. Sze, Physics of Semiconductor Devices (2nd edition), Wiley, 2008.

[5] S. E. Lyshevski, Nano and Micro - electromechanical Systems, CRC Press, 2005.

NST5204 Nanocomposites

Advantage of composite materials, mechanical properties, Thermal, electrical and electronic and optical properties. Super hard nanocomposites-designing and mechanical properties - stress-strain relationship, toughness, strength, and plasticity. Ceramic metal nanocomposites: Ceramic based nano-porous composites, metal matrix nanocomposites, natural nano-bio-composites, thin film nanocomposites, synthesis of various nanocomposites materials.

Introduction to polymer composites, Processing of nanoparticles, binding mechanisms in nanoparticles, dispersion of nanoparticles, and stabilization of nanoparticles. Processing and fabrication of polymer nanocomposites, Melt blending, solvent casting, In-situ polymerization, solution polymerization, template synthesis, high shear mixing.

Natural nanocomposite systems: Spider silk, bones, shells; organic –inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposite material; use of synthetic nanocomposites for bone teeth replacement. Bioactive nanocomposites in bone grafting and tissue engineering, inorganic/polymer nanocomposites for dental restoration and bone replacement applications.

Suggested Books:

[1] P. M. Ajayan, L. S. Schadler and P. V. Braun, Nanocomposite science and technology, Wiley-VCH, 2003.

[2] H .S. Nalwa, Encyclopedia of Nanotechnology, American Scientific Publishers, 2003.

[3] A. D. Pomogailo and V. N. Kestelman, Metalopolymer nanocomposites, Springer-Verlag, 2005.

[4] K. E. Gonsalves, C. R. Halberstadt, C. T. Laurencin and L. S. Nair, Biomedical nanostructures, John-Wiley & Sons, 2008.

[5] C. A. Mirkin and C. M. Niemeyer, Nanobiotechnology II, Wiley- VCH, 2006.

SEMESTER III

Courses

NST651 **Research Project**

NST601 **Major Project I**

NST6401 **Nanobiotechnology**

Historical perspective of integration of biology, chemistry and material science opportunities and promises of nanobiotechnology. Complexity and size of biological molecules– DNA, RNA proteins and carbohydrates; Techniques: Biological analysis electrophoretic and chromatographic analysis– basic principles and applications. Fluorescent probes for analysis of proteins and nucleic acids. Labeling of proteins and nucleic acids by acids by various fluorescent dyes. Bacteria viruses: Prokaryotic complexity and size distribution; Bacterial cell-to-cell communication, quorum sensing, chemotaxis; Microbial production of inorganic nanoparticles; Gold nanoparticles for imaging and therapy.

Nanoparticles, quantum dots, carbon nanotubes, nanofibers, and buckyballs interface with biological macromolecules; Impact of Nanomaterials in biological process; tolerance by immune systems and toxicity; Nucleic acid Engineering: Modifications of DNA for nanotechnological applications, Semiconductor (metal) nanoparticles, nucleic acid, and protein based recognition groups–Application in optical detection methods – Nanoparticles as carrier for genetic material– Nanotechnology in agriculture. Drug delivery, DNA computing, Molecular design using biological selection, Hybrid materials, Future directions.

Suggested Books:

[1] J. M. Berg, Tymoczko, J. L. and L. Stryer, Biochemistry 6thEd, W. H. Freeman and Company, NewYork. 2006.

[2] C. M. Niemeyer and C. A. Mirkin, Nanotechnology: Concepts, Applications and perspectives, Wiley Press. 2004.

[3] D. S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley Press. 2004.

[4] V. Labhasehwar and D. L. Pelecky, Biomedical Applications of Nanotechnology, Wiley Press, 2007.

[5] R .L. P. Adams, L. Knwler and D. P. Leader, The Biochemistry of the Nucleic Acids, Springer, 2007.

NST6403 Nanosensors and Devices

Introduction to sensors, static characteristics and dynamic characteristics, Physical effects: - Photoelectric Effect, Photoluminescence Effect, Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect, Hall Effect, thermoelectric effect, magneto-optical phenomena. Types of sensors- Mechanical, optical, spintronic, bioelectronics and biomagnetic sensors, surface modification, surface materials and interactions and its examples.

Taxonomy of Nano-and Microsystems-Synthesis and Design. Classification and considerations, Biomimetics, Biological analogies, and design–Biomimetics Fundamentals, Biomimetics for NEMS and MEMS. Introduction to modeling, analysis and simulation, modeling developments of micro-and nano actuators using electromagnetic-Lumped-parameter mathematical models of MEMS.

Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Nanosensors and Devices-Interfacing with the Brain, towards molecular medicine, Lab-on-BioChips- Guided evolution for challenges and the solutions in Nano Manufacturing technology.

Suggested Books:

[1] S. E. Lyshevski, Micro-Electro Mechanical and Nano-Electro Mechanical Systems, Fundamental of Nano-and Micro-Engineering – 2nd Ed., CRC Press, 2005.

[2] N. P. Mahalik, Micro manufacturing and Nanotechnology, Springer, Berlin Heidelberg New York, 2006.

[3] M. J. Jackson, Micro and Nanomanufacturing, Springer, 2007.

[4] Z. Cui, Nanofabrication, Principles, Capabilities and Limits, Springer, 2008.

[5] K. Kalantar–Zadeh and B. Fry, Nanotechnology Enabled Sensors, Springer, 2008.

NST6405 Microelectromechanical Systems (MEMS)

Overview of MEMS and Microsystems – Thin film growth and models –Mechanical, Electrical, Thermal properties for Thin Films/MEMS– Measurement techniques– Materials for MEMS- Semiconductors, Metals and Metal alloys, Ceramics, Polymers – Silicon and other substrate materials. MEMS Fabrication – Doping process - Bulk micromachining - Wet & Dry Etching- Isotropic and anisotropic etching and mechanism - Etch stop techniques – DRIE and other processes- Surface Micromachining – LIGA and laser assisted processing – Nanomechanical system fabrication - Fundamentals of Design and Simulation.

Microsystem design – Static bending of thin films –Mechanical vibration–thermomechanics–fracture mechanics – Thermofluidics. Scaling laws in miniaturization – Design considerations – Process and Mechanical design – Finite element method (FEM), Computer aided design CAD – Mircosensors and Microactuators– Optical, chemical, thermal, gas, pressure, bio and mechanical sensors – Nanosensors–Applications in automobile, aerospace, health care, industrial, consumer and telecommunications, Capacitive Accelerometer.

Suggested Books:

[1] Tai-Ran Hsu, MEMS and Microsystems – Design, Manufacture, and Nanoscale Engineering Second Edition, John Wiley & Sons, New Jersey, 2008.

[2] R. Ghodssi and P. Lin, MEMS Materials and Processes Handbook, Springer, New York, 2011.

[3] N. Maluf and K. Williams, An introduction to Micro electro mechanical systems Engineering Second Edition, Artech House, Boston, 2004.

[4] J. A. Francisco, Sensors based on nanostructured materials First Edition, Springer-Verlag, New York, 2008

[5] H. Baltes, O. Brand, G. K. Fedder, C. Hierold, J. G. Korvink and O. Tabata, Enabling Technology for MEMS and Nanodevices, Wiley-VCH, Weinheim, 2004.

NST6301 Nanolithography and Device Fabrication

State of the art (including principles, capabilities, limits, applications) of Optical lithography, Mask Making, Electron lithography, X-ray lithography, Ion lithography, Neutral atomic beam lithography, Plasma-Aided Nanofabrication, Soft Lithography, Nanosphere Lithography, Nano-imprint, Dip-pen nanolithography, key consequences of adopted techniques.

Definition of Technology node, Basic CMOS Process flow. MOS Scaling theory, Issues in scaling MOS transistors: Short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Non-classical MOS transistors. MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issue of high-k. Interface states, bulk charge, band offset, stability, reliability – Qbd high field, possible candidates, CV and IV techniques.

Suggested Books:

[1] Z. Cui, Nanofabrication, Principles, Capabilities and Limits, Springer, NewYork (2008).

[2] H. Howard, Into The Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Series in Materials Science, Springer-Verlag Berlin, 2009.

[3] M. J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization 2nd Edition, CRC Press, California, USA, 2002.

[4] G. F. Cerofolini, Nanoscale Devices, Springer, 2009.

[5] R. Gross, A. Sidorenko and L. Tagirov, Nanoscale Devices – Fundamentals and Applications, Springer, 2006.

NST6303 Plasma Technology

Introduction to plasmas, plasma discharge (dc & rf), microwave discharge, photo-ionization, surface ionization (Q-Machine), and laser-produced plasma, plasma measurements (densities and temperatures), plasma frequency and plasma Debye length, Langmuir probe, the formation of plasma sheath, plasma sheath width (expression).

Synthesis of carbon nanotubes (CNTs) and carbon nanofibers (CNFs), Graphene, g - CNT Composites using plasma enhanced CVD (dc and rf) and microwave plasma enhanced CVD, growth mechanism (tip growth mode, base growth mode and vertically aligned CNTs/CNFs), plasma etching, Plasma Electronics (Field Emission properties) and aspect ratio.

Role of Plasma in High Power Microwave Devices, Free Electron Laser (FEL) growth rate, Gain and Efficiency, Cerenkov Free Electron Laser (CFEL) (growth rate, Gain and Efficiency), and Gyrotron. Role of plasma dust grains in Fusion devices- Tokamak and International Thermonuclear Experimental Reactor (ITER). Laser-Driven Accelerators: Laser -Beat Wave Accelerator (LBWA) and Laser Wake Field Accelerator (LWFA).

Suggested Books:

[1] K. Ostrikov and S. Xu, Plasma-Aided Nanofabrication: from plasma sources to Nanoassembly, Wiley-VCH, Weinheim, Germany, 2007

[2] M. A. Lieberman and A. J. Lichtenberg, Principles of Plasma Discharges and Material Processing, Wiley Interscience Publications, USA, 1995.

[3] C. S. Liu and V.K. Tripathi, Interaction of Electromagnetic Waves with Electron Beams and Plasmas, World Scientific, Singapore, 1994.

[4] C.W. Roberson and P. Sprangle, A Review of free electron lasers, Physics of Plasmas, 1(1), P. 3, AIP Publishing, 1989.

NST6305 Nanotechnology for Medical Diagnostic and Therapy

Nanotechnology for Disease Diagnostics: Quantum dot conjugation strategies with DNA-aptamer, Protein and Antibody and FRET/BRET based assays for Cancer, AIDS, tuberculosis and other disease diagnostics; Nanoparticle assisted multiplexed diagnostic assays (Bio barcode amplification assay, Sandwich DNA assay, Eliza) and point-of care diagnostics (Lateral flow assay).

Nanotechnology for Drug delivery: Lipid, polymeric, Hyaluronic acid and heparin functionalized core shell nanoparticle as drug delivery vehicles; Carbon nanotube-based vectors for delivering immunotherapeutics and drugs, Hydrogels for drug delivery, nanoparticle induced Gene delivery for gene therapy.

Nanotechnology for therapy: Nanodrugs for treatment of cancer (abraxane and other drugs); concept of nanodrugencapsulation, self-assembly, controlled release (targeted and triggered release), nanoparticle recovery; modified Ag-nanoparticle for Photodynamic Therapy of cancer; nanoparticle assisted vaccine development; nanoshells for surgical procedures.

Suggested Books:

[1] C. Kumar, Nanomaterials for Medical Diagnostics and Therapy, Wiley-VCH, 2007.

[2] H. F. Tibbals, Medical Nanotechnology and Nanomedicine, CRC Press, 2010.

[3] K. K. Jain, The handbook of Nanomedicine, Humana Press, 2008.

NST6201 Spintronics

History and overview of spin electronics; Classes of magnetic materials; The early history of spin; Quantum Mechanics of spin; The Bloch sphere; Spin-Orbit interactions and Hall effect; Anomalous Hall Effect, Spin Hall Effect, Inverse Spin Hall Effect Exchange interaction.

Spin relaxation mechanisms; Basic electron transport; Anisotropic magnetoresistance, Spin-dependent transport; Giant Magneto Resistance (GMR) effect, Tunnel Magnetoresistance (TMR) Spin dependent tunneling; Andreev Reflection at ferromagnet and Superconductor interfaces; Spin transfer torques; Spin-transfer drive magnetic dynamics.

Current-driven switching of magnetization and domain wall motion; Domain wall scattering and Current-Induced switching in ferromagnetic wires; Spin injection, spin accumulation, and spin current.

Silicon based spin electronic devices, Spin LEDs: Fundamental and applications, Electron spin filtering, Materials for spin electronics: Heusler Alloys and DMS, Spin-Valve and spin-tunneling devices: Read Heads, MRAMS, Field Sensors, Spin transistors, Quantum Computing with spins.

Suggested Books:

[1] S. Bandyopadhyay and M. Cahay, Introduction to Spintronics, CRC Press, 2008.

[2] M. Johnson, Magnetoelectronics, Academic Press, 2004.

[3] D. J. Sellmyer and R. Skomski, Advanced Magnetic Nanostructures, Springer, 2006.

[4] S. Maekawa, Concepts in Spin Electronics, Oxford University Press, 2006.

[5] D. D. Awschalom, R. A. Buhrman, J. M. Daughton, S. V. Molnar, and M. L. Roukes, Spin Electronics, Kluwer Academic Publishers, 2004.

NST6203 Biophotonics

Electromagnetic properties of nanostructures – Wavelength and Dispersion laws– Density of states – Maxwell and Helmholtz equations – Photonic band-structure and photonic band gap- Propagation of light in periodic media. Band structure in periodic media– 1D and 2D cases. Light absorption in cells– Light induced cellular processes– photochemistry induced by exogenous photosensitizers– Interaction of light with tissues: Nature of Optical interactions– Measurement of optical properties of a tissue Light-induced Processes in Tissues–Autofluorescence, photochemical processes, thermal effects, photoablation, plasma induced ablation and photodisruption.

Nanotechnology for Biophotonics: interface of bioscience, nanotechnology and photonics- Semiconductor quantum dots for bioimaging– Metallic nanoparticles and nanorods for Biosensing– Up-converting nanophores- Inorganic nanoparticles– Pebble nanosensors for Invitro Bioanalysis- Nanoclinics for optical diagnostics and Targeted therapy. Biomaterials for Photonics: Photonics and Biomaterials– Bioderived materials (Baceriorhodopsin, Green Fluorescent Protein, DNA, Bio-objects and biocolloids) Bioinspired materials– Biotemplates (DNA and Viruses as templates)– Bacteria as synthesizers for photonic polymers.

Suggested Books:

[1] S. V. Gaponenko, Introduction to Nanophotonics, Cambridge University Press, New York, 2010.

[2] J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals (2nd edition), Princeton University Press, 2008.

[3] P. N. Prasad, Introduction to Biophotonics, John Wiley and Sons, New Jersey, 2003.

[4] B. C. Wilson, V. V. Tuchin and S. Tanev, Advances in Biophotonics, IOS Press, 2005.

[5] H. Masuhara, S. Kawata and F. Tokunaga, Nano Biophotonics: Science and Technology, Elsevier, 2007.

SEMESTER IV

Courses

NST652 Research Project

NST602 Major Project II

DEPARTMENT OF BIOTECHNOLOGY
DELHI TECHNOLOGICAL UNIVERSITY
Programme : M.Tech. (Bioinformatics)
Programme Specific Outcomes

1. Interpret relationships among living things, analyze, and solve biological problems, from the molecular to ecosystem level using basic biological concepts, grounded in foundational theories.
2. Develop skills in bioinformatics research techniques and applying therm to primary research questions, and make well-supported scientific conclusion that link basic biology and computational technique.
3. Apply programming tools to gene prediction problems through the development of novel tools and software and to develop ability to use existing and write new database code to access and manipulate genetic data.
4. Analyze and apply appropriate bioinformatics tools and bioinformatics techniques to analyze and interpret data for investigating complex problems in biotechnology Engineering and related fields.
5. Apply modern computational tools and techniques to biological data sets, consisting of genomic transciptomic, and ecological data.

SCHEME OF TEACHING AND EVALUATION
MASTER OF TECHNOLOGY IN BIOINFORMATICS (BIO)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	BIO501	Introduction to Bio-informatics	Core	4	3	0	2	15	25	20	40	-	17
	2	BIO503	Advanced Proteomics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	BIO5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15/20	25/-	20/30	40/50	-	
	4	BIO5301/5303/.....	Elective 2	Elective	3	3	0/1	2/0	15/20	25/-	20/30	40/50	-	
	5	BIO5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	BIO502	Advances in Bio-informatics	Core	4	3	0	2	15	25	20	40	-	17
	2	BIO504	High Throughput Structural Biology	Core	4	3	0	2	15	25	20	40	-	
Group D	3	BIO5402/5404/.....	Elective 4	Elective	4	3/4	0	2/0	15/20	25/-	20/30	40/50	-	
	4	BIO5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	BIO5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	BIO651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	BIO601	Major Project I	Core	3						40	60		12
	2	BIO6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	3	BIO6301/6303/.....	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	BIO6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group F	1	BIO652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	BIO602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	BIO5401	Computer Graphics	Elective	4	3	0	2	15	25	20	40	-
	2	BIO5403	Computer Aided Drug Design		4	3	0	2	15	25	20	40	-
	3	BIO5405	Pharmacogenomics and Personalized Medicine		4	3	0	2	15	25	20	40	-
	4	BIO5407	OMICS in Medicine		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	BIO5301	Data Warehousing and Data Mining	Elective	3	3	0	0	20	-	30	50	-
	2	BIO5303	Genomics: From Human Genome Project to Medical Applications		3	3	0	0	20	-	30	50	-
	3	BIO5305	Combinatorial Methods in Biopharmaceuticals		3	3	0	0	20	-	30	50	-
	4	BIO5307	Microarray Technology		3	3	0	0	20	-	30	50	-
	S.No.	Course Code		Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	BIO5201	Open Area Seminar - I		2	2	0	0		-	0	100	-
Elective 3	2	BIO5203	Analysis of Biological System	Elective	2	2	0	0	20	-	30	50	-
	3	BIO5205	Plant Bioinformatics		2	2	0	0	20	-	30	50	-
	4	BIO5207	Database Management System		2	2	0	0	2	-	100	-	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	BIO5402	Advanced Genetic Engineering	Elective	4	3	0	2	15	25	20	40	-
	2	BIO5404	Systems Biology		4	3	0	2	15	25	20	40	-
	3	BIO5406	Web Application Development		4	3	0	2	15	25	20	40	-
	4	BIO5408	Image Processing in Medicine		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	BIO5302	Minor Project	Elective	3	3	0	0	-	40	0	0	60
	2	BIO5304	Medical Bioinformatics		3	3	0	0	20	-	30	50	-
	3	BIO5306	Pharmacoinformatics		3	3	0	0	20	-	30	50	-
	4	BIO5308	Immunoinformatics		3	3	0	0	20	-	30	50	

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	BIO5202	Open Area Seminar-II	Elective	2	2	0	0	-	-	100		-
	2	BIO5204	Python programming for Bioinformatics		2	2	0	0	20	-	30	50	-
	3	BIO5206	Bioethics and IPR		2	2	0	0	20	-	30	50	-
	4	BIO5208	Perl Programming for Bioinformatics		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	BIO6401	Drug Design and Discovery	Elective	4	3	0	2	15	25	20	40	-
	2	BIO6403	Neurobiology		4	3	0	2	15	25	20	40	-
	3	BIO6405	Cell and Molecular Biology		4	3	0	2	15	25	20	40	-
	4	BIO6407	Biostatistics		4	4	0	0	20		30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	BIO6301	Nanotechnology in Healthcare	Elective	3	3	0	0	20	-	30	50	-
	2	BIO6303	Resource Planning and Management in Bioinformatics		3	3	0	0	20	-	30	50	-
	3	BIO6305	Advanced Drug Delivery Systems		3	3	0	0	20	-	30	50	-
	4	BIO6307	Artificial Intelligence		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	BIO6201	Design and Analysis of Algorithms	Elective	2	2	0	0	20	-	30	50	-
	2	BIO6203	Molecular Evolution		2	2	0	0	20	-	30	50	-
	3	BIO6205	Molecular and Cellular Biophysics		2	2	0	0	20	-	30	50	-
	4	BIO6207	Entrepreneurship		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

BIO501 Introduction to Bioinformatics

Overview of the biological databases and their types, Sequence Formats & storage along with Sequence submission to sequence Database, computational genomics, Human Genome Project, Gene ontology, Pairwise and Multiple sequence alignment, Local and Global alignment, Scoring matrices, Gaps, Dot Plots. Dynamic programming Approach: Needleman and Wunsch Algorithm, Smith and waterman Algorithm, Heuristic Approach: BLAST, FASTA. Methods for multiple sequence alignment.

Practicals

1. Inter-conversion different sequence file format
2. Database Searching using Entrez and SRS
3. Study of Databases and Data retrieval
4. Dot Matrix Alignments
5. Needleman Wunsch Alignments.
6. Smith Waterman Alignments
7. Multiple Sequence Alignment

Suggested Books:

1. Arthur M. Lesk ,Introduction to Bioinformatics, Oxford University Press, 2003.
2. David W. Mount ,Sequence and Genome Analysis , Cold Spring Harbor Laboratory, 2004.
3. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins,Wiley-Interscience, 2004.
4. D Higgins, W Taylor ,Sequence structure and Database, Oxford press ,2003.

BIO503 Advanced Proteomics

The Introduction of this subject includes the information of proteome and the Genome, life and death of a protein, its modular structure and various functional protein families. It would be giving insights for the need, scope and the challenges of proteomics. The Strategies required for protein separation like Two-dimensional polyacrylamide gel electrophoresis for proteome analysis, a brief history of 2-DE, 2-DE with immobilized pH gradients, sample preparation, solubilisation, Reduction, The first dimension: IEF with IPG, Equilibration between dimensions and the second dimension: SDS-PAGE, resolution, reproducibility of 2-DE, liquid chromatography in proteomics. In the next section the subject covers how to detect proteins in polyacrylamide gels and on electroblot membranes with Organic dyes, silver and reverse stains, Colloidal dispersion stains, organic fluorophore stains and metal chelate stains. This chapter further gets into Image analysis of two-dimensional gels and learning Data acquisition, digital image processing, Protein spot detection and quantification, Gel matching, Data analysis and presentation. The students will study how to enhance the high-throughput proteome analysis, the impact of stable isotope labelling, Sample preparation and two-dimensional gel separation. Other techniques like Mass spectrometry which includes protein

identification using MS data, protein identification using MS/MS data. And a little overview to Protein modification in proteomics, phosphor-proteins, glycoproteins, and Ubiquitin etc. Next it includes protein – protein interaction and its technique like Yeast two hybrid, Co-Precipitation, Phage Display, Phylogenetic Profile, Domain fusion, Gene Neighborhood, Gene Cluster, Mirror Tree. And students also learn analysis of genome wide Protein-Protein Interactions in yeast, Genome wide yeast two hybrid analysis of other organisms and Protein fragment complementation assays. Last section comprises of functional proteomics and introduction, types, detection and quantification of proteins bound to protein chips, also the emerging proteins chips technologies.

Practicals:

1. Isolation of protein
2. Protein estimation
3. SDS- PAGE
4. Antibody staining
5. Protein interaction
6. Database analysis

Suggested Books:

1. S.R. Pennington and M.J. Dunn,Proteomics: From Protein Sequence to Function, Viva Books Private Limited ,2001.
2. Daniel C. Liebler,Introduction to Proteomics, Humana Press,2002.
3. A.M. Campbell, Discovering Genomics, Proteomics & Bioinfo ,C.S.H. Press,2003.
4. C Saccone, G Pesole, Handbook of Comparative Genomics: Principles and Methodology, Wiley-LISS Publication ,2003.
5. S.R. Pennington, M.J. Dunn , Proteomics: From Protein Sequence to Function,Viva Books Private Limited ,2001.

BIO5401 Computer Graphics

The introduction to graphic Systems and its various types like, Refresh CRT, raster-scan displays, DVST, plasma displays and LCD. Also the introduction to input devices and the functions and working provided by them, including the example like image scanners, touch panels, Input modes, request mode and event mode. The basics of output primitives like Points, lines, DDA, Bresenham live & circle drawing algorithm and ellipse generation. Along with output, filled area primitives are also included in this like scan line polygon fill algorithm, inside outside tests, boundary fill algorithm with understanding of Line width, color, gray levels and character attributes. In the next section it have basics of two-dimensional geometric transformation including translation, rotation, fixed point scaling and general scaling direction. The viewing pipeline, window viewpoint transformation and Line clipping algorithms. The next unit is based on three dimensional concepts like Polygon surfaces, plane equation, curved lines, quadric surfaces, spline representation and specification. Other things include Bezier curves and surfaces, B-splines and surfaces, Displaying spline curves and surfaces and Horner's rule The viewing methods of 3 D transformations includes viewing co-ordinates, transformation from world to viewing co-ordinates, parallel and perspective projections, Back face detection, depth-buffer and A-buffer methods.

In the end the syllabus includes the representation of 3D Object byVisible Surface Algorithms, Curves and Surfaces in Computer Graphics, also introduction to the Ray Tracing and Radiosity methods, Anti-aliasing, Shadow generation, Texture mapping, Effects, Fractals, and Image Coding.

Practicals:

1. Standard functions in the 'c' graphics module -Introduction to pixels, drawing various geometric objects, filling polygons, images etc.
2. Implementation of the basic line drawing algorithm and the Circle drawing algorithm using DDA, Midpoint algorithm, Bresenham's algorithm etc.
3. Polygon filling using seed fill, scan line algorithm etc.
4. Clipping algorithms -Cohen-Sutherland algorithm, LiangBarsky algorithm etc.
5. 2D and 3D Transformations -Translation, scaling, rotation etc.
6. Projections - Parallel and perspective projections and their types. Curve fitting -Cubic curves (Bezier curves, spline curves etc.) 7. Lighting and Shading -Implementing Phong illumination model, Gouraud and Phong shading, Animation.
8. Image processing demonstration

Suggested Books:

1. D.Hearn and M.P. Baker ,Computer Graphics C version, Pearson Publication,1987
2. S.Harriyton ,Computer Graphics - A programming approach, Mc Graw Hill Education , 1987
3. David F. Roger , Procedural Elements of Computer Graphics, Mc-Graw Hill Education, 1997

BIO5403 Computer Aided Drug Design

The subject starts with the introduction to CADD, SBDD and Representation of Molecular Structures, Chemical Nomenclature and Structure Representation, Processing Constitutional Information, Representation of 3D Structures, Molecular Shape Analysis, and representation of Chemical Reactions. Then next it have Virtual screening which includes Chemoinformatics in Lead Discovery, Computational Chemistry, Molecular Complexity and Screening Set Design. There are Algorithmic Engines in Virtual Screening and students learn the strengths and Limitations of Pharmacophore-Based Virtual Screening. Moving towards the lead discovery part which comprises of High Throughput Screening, Hit and Lead Discovery, Enhancing Hit Quality and Diversity within Assay Throughput Constraints, Molecular Graphics, Molecular Dynamics and Simulation of Lead. Also get to understand the Molecular Diversity in Lead Discovery from Quantity to Quality and In Silico Lead Optimization. The next part include Databases and Libraries like PubChem, PubEchm-BioAssay, Pharma Project, Drug Bank, WOMBAT: World of Molecular Bioactivity, Cabinet - Chemical and Biological Informatics Network. It gives Structure Modification in Chemical Databases, Rational Design of GPCR-specific Combinational Libraries Based on the Concept of Privileged and Substructures. The last and the main part of the Molecular docking & Simulation in which students study de novo pharmacophore elucidation/ drug design for structurally well-defined receptor targets like HIV protease inhibition, ER antagonism, H2 receptor antagonism.

The introduction to Chirase inhibition (quinoline derivative antibiotics), ACE inhibition and docking like macromolecule-ligand docking, docking algorithms and AUTODOCK. The syllabus also includes Molecular dynamic simulations, relative energy, energy minimization methods, ligand binding free

energy calculations (both simulation and empirical methods), intermolecular interactions, forces related to drug binding, force-field calculation including solvation, role of solubility in drug binding and pKa, Poisson-Boltzmann Surface Area (PBSA), AMBER, GROMOS and GROMACS.

Practicals:

1. To perform the homology modeling of a protein by using the MODELLER software.
2. To evaluate the 3D structure of a protein by using the different tools on the SAVS server.
3. To find the active site/cavity in a receptor by using the SURFACE RACER program.
4. To draw the chemical structures by using the ChemSketch/ChemDraw software.
5. To perform the de novo Drug Designing by using the LIGBUILDER software.
6. To perform the protein-ligand docking by using the HEX program.
7. To perform the protein-protein docking by using the AUTOCOCK software.
8. To perform the virtual screening of ligands by using the DOCK program.
9. To perform the Quantitative Structure-Activity Relationship (QSAR) analysis by using the DRAGON software.
10. To perform the Pharmacophore modeling of ligands by using the LigandScout program.

Suggested Books:

1. B.Wang, S.Ekins Computer Applications in Pharmaceutical Research and Development, John Wiley & Sons India Pvt. Ltd,2006
2. R.V. Gadag and A. Nityananda Shetty ,Engineering Chemistry,I.K. International Publishing House Pvt. Ltd,2014
3. Juan Alvarez and Brian Shoichet,Virtual Screening in Drug Discovery, CRC Press,2005
4. Donald T. Haynie ,Biological Thermodynamics,Cambridge University Press India Private Limited,2008

BIO5405 Pharmacogenomics and Personalized Medicine

The course gives introduction to pharmacogenomics, its historical perspectives and current status. It covers an important topic like The Human genome or Computational genome analysis. Further it gives functional analysis of Gene Variation & Genotyping Techniques with aspects influencing method of selection, SNP Genotyping and TaqMan Genotyping. Next it provides insights of Pharmacogenomics in drug discovery and the need of protein structure information, variation in drug targets-the scale of problem, mutation of drug targets leading to change in the ligand binding pocket and PharmGKB.

Practicals:

1. Accessing, querying and becoming comfortable with the interface of pharmacogenomics based databases: UCSC, NCBI dbSNP, HapMap and resequencing databases, 1000 Genomes, PharmGKB - a publicly available Internet tool to aid researchers in understanding how genetic variation among individuals contributes to differences in reactions to drugs and Drug Bank
2. Use of PGx pipeline 1.0 Server

3. Statistical data management using SAS: Data Collection and Entry, Data Storage and Transferal, Data Analysis & Data Exposition

4. Understand and run Warfarin dosing algorithm using web based interfaces Sequence variation analysis

Suggested Books:

1. Licinio, Julio and Ma-Li Wong, Pharmacogenomics: The Search for the Individualized Therapies", Wiley-VCH, 2002

2. Chakrabarthy, Chiranjib and Bhattacharyya,Pharmacogenomics: An Approach to New Drugs Development, Atane, 2004.

3. Mark A. Rothstein, Pharmacogenomics: Social, Ethical and Clinical Dimensions,Wiley-Liss, 2003.

4. QYan Pharmacogenomics in Drug Discovery & Development, Humana Press, 2008

BIO5407 OMICS in Medicine

The introduction to Omics concepts and applications, with sequencing of Human and other organisms. It help students understand the role of Genomics in identification of microbes causing infectious diseases (microbiomes study), molecular epidemiology, host resistance to infection, pathogenicity and combating infectious diseases. It explains how genomics helps in detection of genetic disorders, treatment and pharmacogenomics. The understanding of role of Epigenomics and non-coding RNAs in disease development, inheritance and control. The last part includes genomics in translational and clinical trials, and risk assessments/prediction of genetic diseases with few successful case studies.

Suggested Books:

1. T. Strachan and A.P. Read ,Human Molecular Genetics,Garland Science Publication,2003

2. H. Lodish, A. Berk, and C.A.Kaiser,Molecular Cell Biology, W. H. Freeman & Co Ltd,2007

3. Victor J. Dzau and Choong-Chin Liew,Cardiovascular Genetics and Genomics for the CardiologistBlackwell Publishing,2007

4. Charles R. Cantor and Cassandra L. Smith,Genomics: The Science of Technology Behind the Human Genome Project,John Wiley & Sons,1999.

5. M Keynes, A.W.F.Edwards and R Peel ,A Century of Mendelism in Human Genetics,CRC Press,2005

6. T Strachan , J Goodship, P Chinnery ,Genetics and Genomics in Medicine, Garland Science,2014

7. Stephen T Sonis,Genomics, personalized medicine and oral disease,Springer publisher,2015

BIO5301 Data Warehousing and Data Mining

The course starting with the data warehousing Components like Building and Mapping the Data Warehouse to a Multiprocessor Architecture, DBMS Schemas for Decision Support like Data Extraction, Cleanup, and Transformation Tools like Metadata, reporting, Query tools and Applications like Online Analytical Processing (OLAP) and Multidimensional Data Analysis. Next in course is data mining functionalities like Data Pre-processing, Data Cleaning, Data Integration and Transformation which includes Data Reduction, Data Discretization and Concept Hierarchy Generation. Then the students will get to know Efficient and Scalable Frequent Item set in Mining Methods and Various Kinds of Association Rules like Association Mining to Correlation Analysis and Constraint-Based

Association Mining. The course will also include the issues regarding Classification and Prediction like Classification by Decision Tree, Bayesian Classification, Rule Based Classification, Classification by Back propagation, Support Vector Machines, Associative Classification, Lazy Learners and Other Classification Methods, Evaluating the Accuracy of a Classifier or Predictor, Ensemble Methods like Model Section Cluster Analysis: - Types of Data in Cluster Analysis. The course ends with Practical Factors used Prior to Data Mining, Differential Gene Expression, Discriminant Analysis, Gene Annotation, Pathway Analysis, Microarray and Data Mining Applications.

Suggested Books:

1. J Han, M Kamber,Data Mining Concepts and Techniques, Elsevier,2008
2. A Berson,Stephen J. Smith, Data Warehousing, Data Mining & OLAP, McGraw – Hill Publication,2007
3. K.P. Soman, S Diwakar ,V. Ajay,Insight into Data mining Theory and Practice,Prentice Hall of India, 2006.
4. G. K. Gupta,Introduction to Data Mining with Case Studies,Prentice Hall of India, 2006.
5. Pang-Ning Tan,M Steinbach,V Kumar,Introduction to Data Mining, Pearson Education, 2007.

BIO5303 Genomics: From Human Genome Project to Medical Applications

Introduction to the terms liken Gene Medicine, Disease Models and understanding the impact of Genomics on Medicine, and Molecular Medicines. Understanding the Human Genome Project Breakthroughs and Functional Genomic including Comparative Genomics, Transcriptomics, Proteomics, and Mutational Genomics. The course also includes the Genomics Applications in Infectious Diseases topic which helps in identification of causative microbes, molecular epidemiology, host resistance to infection, pathogenicity and combating infectious diseases.

Genomics Applications in Genetic Diseases, detection and treatment of single gene disorders, analysis of polygenic disorders, linkage analysis, Linkage disequilibrium mapping, haplotypes, MHC, and pharmacogenomics. Next it have genomics Applications in Cancer which includes molecular basis of cancer, impact of genomics on cancer research, methods for the diagnosis of cancer and approaches to cancer therapy.

Suggested Books:

1. T. Strachan and A.P. Read, Human Molecular Genetics, Garland Science Publication,2003
2. H. Lodish, A. Berk, and C.A. Kaiser,Molecular Cell Biology, W. H. Freeman & Co Ltd,2007
3. Victor J. Dzau and Choong-Chin Liew, Cardiovascular Genetics and Genomics for the Cardiologist, Blackwell Publishing,2007
4. Charles R. Cantor and Cassandra L. Smith,Genomics: The Science of Technology Behind the Human Genome Project, John Wiley & Sons,1999

BIO5305 Combinatorial Methods in Biopharmaceuticals

Introduction to the Original Combinatorial Chemist, Biopolymers which constitute natural libraries, Selection and evolution .Includes the expression of genetic information Combinatorial assembly of antibody gene and Molecular solutions to Combinatorial problems. It also gives introduction to the synthetic peptide libraries which have Solid-Phase peptide synthesis and Peptide on pins like topic. Other iterative disconvolution strategies, examples of Split/Couple/Mix Peptide Libraries:- Positional

Scannin, the course gives insights to topics like Polystyrenes, PEG, Grafted supports, Coupling strategies, New resins and linkers, Ring, forming cleavage. The students will also learn about the Polyethylene glycols, Dendrimers Fluorous synthesis, and Solutions like Phase parallel synthesis scavenging resins, Ion Exchange resins, Supported reagents, Flourous reagents ,Solid phase extraction, Gas Phase separation. In the last section we have Product identification, Gel Phase NMR, High resolution magic angle spinning NMR on-bead infrared Spectroscopy, Mass Spectroscopy, Non Spectroscopic Methods, Product identification, Gel Phase NMR , High resolution magic angle spinning NMR on-bead infrared Spectroscopy, Mass Spectroscopy and Non Spectroscopic Methods.

Suggested Books

1. F Hicham, Combinatorial Chemistry, Oxford University Press, 2000
2. Block J.H. and Beale, J.M., Wilson & Gisvolds Text book of Organic Medicinal and Pharmaceutical Chemistry, Lippincott Williams & Wilkins, 2004
3. Fassina, G.,Combinatorial Chemistry and Technologies: Methods and Applications, CRC Press, 2005
4. G Jung ,Combinatorial Chemistry: Synthesis, Analysis, Screening, WILEY-VCH , 2001
5. K. C. Nicolaou ,Handbook of Combinatorial Chemistry: Drugs, Catalysts, Materials, Wiley-VCH, 2002

BIO5307 Microarray Technology

Starting with the types of microarray like cDNA microarray, oligonucleotide microarray, spotted microarray and In situ synthesized microarray along with them Hybridization process andDNA microarray database. In In situ synthesized microarray student will study method of manufacturing and Phosphoramidite method. Spotted microarray include method of manufacturing, and Photolithography. The next section includes image segmentation, intensity measurement, Normalization of data, Clustering and Coexpression analysis. And the last section comprises of Applications of microarray technology which includes Differential gene expression analysis, Expression profiling, Genome sequencing, Copy number variation, Alternative splicing detection, and Mutation analysis.

Suggested Books:

1. H. Causton, J. Quackenbush,A. Brazmam, Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide, Blackwell, 2003
2. D.P. Berrar, W. Dubitzky, M. Granzow,A Practical Approach to Microarray Data Analysis,Springer, 2003
3. S. Drăghici ,Data Analysis Tools for DNA Microarrays,Chapman and Hall/CRC, 2003
4. F. Emmert-Streib, M. Dehmer, Analysis of Microarray Data: A Network-Based Approach,Wiley-VCH Verlag GmbH & Co., 2008

BIO5201 Open Area Seminar - I

BIO5203 Analysis of Biological Networks

At first there is introduction to the biological networks which includes Systems Biology, Properties of Biological Networks and Graph Theory which have Basic Notation, Special Graphs, Graph Representation and Graph Algorithms. The next section is about the network analysis in which students read about Global Network Properties, Global Properties of Complex Networks, Models of

Complex Networks, Additional Properties of Complex Networks, and Statistical Testing of Network Properties.It also have Network Centralities in which Centrality Definition and Fundamental Properties Degree and Shortest Path-Based Centralities and Feedback-Based

Centralities are studied. The course also include network motifs as topic which include Definitions and Basic Concepts, Motif Statistics and Motif- Based Network Distance, Complexity of Network Motif Detection, Methods and Tools for Network Motif Analysis, Analyses and Applications of Network Motifs. The next topic is network clustering in which students will study Network Clustering Problem, Clique-Based Clustering, and Centre-Based Clustering. The last section of the course is about Signal Transduction and Gene Regulation Networks, Protein Interaction Networks, Metabolic Networks, Phylogenetic Networks and Ecological Networks.

Suggested Books:

1. A Raval, A Ray, Introduction to Biological Networks,Chapman and Hall/CRC,2013
2. Tatiana V.Tatarinova, Y.Nikolsky ,Biological Networks and Pathway Analysis, Humana Press, 2017

BIO5205 Plant Bioinformatics

Introduction to Plant Bioinformatics and explain importance of plant bioinformatics includes biological databases and Protein and Gene Information Resources like PIR, SWISSPROT, PDB and genebank. Comprises of Plant specific Genomic Data and Resources like HarvEST, TARI Database, Legume Resources, GrainGenes, Maize GDB and Gramene. Phylogenetic data and phylogenies Software used to discover phylogenies, use and status of specimen data, species distribution, Current priorities in biodiversity informatics, challenges and future prospect. The course also introduce KEGG tools and Resources and Germplasm Data Management. In the last section the course talks about PlantGDB Resources, Gene Ontology, Manual Annotations, and Computational Annotation Methods.

Suggested Books:

1. D Edwards, Plant Bioinformatics: Methods and Protocols, Humana Press, 2007
2. Dary I .J. Somers, P.Langridge and J. Perry Gustafson, Plant Genomics: Methods and Protocols,Humana Press, 2009.

BIO5207 Database Management System

Introduction to DBMS vs. File-system, Data models, architecture (2-Tier & 3-Tier), Database users and DBA. Understanding the Database Design: Design issue, E R Model: entity, entity set, attribute (single valued, multivalued, simple, composite & derived), Constraints – Mapping cardinalities, Keys, ER Diagram: Basic structure, Mapping, Specialization, Generalization, Weak entity Relational Model: Database schema & instance. The students will learn relation: schema & instance, attribute, domain, tuple, domain constrains, arity & cardinality of relation, integrity constraint, key constrains (super key, candidate key, primary key), Foreign Key Constraints. SQL: DDL (Create, Alter, Drop), DML (Insert, Update, Delete) & Concept of DCL. The last section would include Aggregation Functions (max, min, avg and sum). Nested query and Normalization: Different anomalies in designing a Database, Normalization concept. 1NF, 2NF & 3NF

Suggested Books:

1. A Silberschatz, Henry F. Korth, and S. Sudarshan ,Database System Concepts , Mc Graw-Hill Publication , 2010
2. J Gehrke, R Ramakrishnan,Database Management Systems,Mc Graw-Hill Education,2003

SEMESTER II

BIO502 Advanced Bioinformatics

Human Genetic Variation and its Databases, Tools for SNP and mutation visualization, Biological Sequence Analysis & Characterization which includes Predictive Functional Analysis of coding and non-polymorphisms, Also include Amino Acid Properties and Consequences of Substitutions, Relationship between genotypes and phenotypes; Monogenic and complex disorders; Interplay of genetic and environmental factors; Integration of clinical and molecular data; Understanding the factors influencing disease susceptibility, Soft computation, machine learning, Supervised and Unsupervised Methods, Pharmacogenomics and Pharmacogenetics

Practicals:

1. SNP and Mutation Databases
2. Gene Ontology
3. Predictive Functional Analysis of SNPs – SIFT; PolyPhen
4. Pharmacogenomics Databases

Suggested Books

1. F Dardel, F Képès, N Hardy ,Bioinformatics: Genomics and Post-Genomics,John Wiley & Sons India Pvt Ltd,2006
2. N J Chikhale,V S Gomase, Bioinformatics:Theory and Practice, Himalaya Publication House,2007
3. Campbell ,Heyer,Discovering Genomics, Proteomics and Bioinformatics,Pearson Education,2006
4. N J Chikhale,V S Gomase ,Proteomics: Theory and Practice, Himalaya Publication House,2009
5. Christoph W. Sensen ,Essentials of Genomics and Bioinformatic, John Wiley & Sons India Pvt Ltd, 2003

BIO504 High-throughput Structural Biology

Introduction to the Peptide Bonds, hydrogen bonding, ionic and hydrophobic interactions. Introduction to Protein Structure: Reverse Turns and Organized Folds, Structure Classification, Folding Mechanisms, Bond lengths, bond angles and torsion angles, Degrees of freedom, Cyclic molecules. Rotation About a bond, Eulerian angles Helices and their notations. Analysis and manipulation of structures, Ramachandran plots, Chaperones and Chaperonins, Structure Determination, Dynamics Simulation, Protein Folding, Nucleic Acid Structure- DNA/RNA, Structural Biology for the Optimization of Gene Therapy Vectors, Hands-on assembly of amino acid and nucleotide dimer CPK models. A brief description of X-ray Crystallography Computing: The Phase Problem, Least Square Solutions, Entropy Maximization, and Indirect Methods. Also explains NMR Structure Determination: Nuclear Magnetic Resonance, Distance Geometry, Distance-based Modeling, and Structural Analysis. This section gives description about Optical spectroscopy including Absorbance spectrum and melting of a protein, circular dichroism, molecular chirality, structural transitions of macromolecules, and analysis of spectral results, ligand binding, and cell sorting, Circular dichroic spectrum and melting of a protein, radiation, radioactive decay, particle detection, liquid scintillation, surface Plasmon resonance, Thermodynamics of macromolecular transitions. The next section of course explains Mass spectroscopy: application to complex proteins and gives Diffraction overview, crystallization, wave/vector math and scattering, scattering from a periodic lattice, reciprocal space, and symmetry

multi wavelength anomalous diffraction and Crystallographic statistics.Potential Energy Function, Local Optimization, Global Optimization, Energy Transformation. Knowledge-based Protein Modeling: Sequence/Structural Alignment, Fold Recognition/Inverse Folding, Knowledge-based Structural Refinement, Structural Computing, Comparative and ab initio modelling

Practicals:

1. Chemical modification of proteins.
2. Peptide mapping.
3. Analysis of amino acid composition.
4. Analysis and interpretation of spectrophotometric data for denaturation studies.
5. Analysis of CD data.
6. Analysis and interpretation of NMR data
7. Crystallization of Lysozyme – pH driven and salt driven crystallization. Effect of
8. concentration. BMCD.
9. Analysis and interpretation of X-Ray crystallographic data.
10. Public domain software for structure modeling and visualization.

Suggested Books

1. D. L. Nelson and M.M. Cox, Lehninger, W. H. Freeman, Principles of Biochemistry,2004
2. M Sundström, M Norin, A Edwards, Structural Genomics and High-Throughput Structural Biology,CRC Press, 2006.
3. P.R. Bergethon, The Physical Basis of Biochemistry: The Foundations of Molecular Biophysics, Springer, 2000.
4. K.E van Holde, C.Johnson,P.Shing Ho, Principles of Physical Biochemistry, Prentice Hall, 2005.
5. Zhijun Wu, Lecture Notes on Computational Structural Biology World, Scientific Publishing Co. Pvt. Ltd, 2008.

BIO5402 Advanced Genetic Engineering

Course includes of core techniques in gene manipulation which involves various steps such as Core techniques in gene manipulation: Cutting and joining DNA, introduction of DNA into cells, Isolation, sequencing and synthesis of gene. Cloning strategies, construction of genomic libraries and cDNA libraries. Probe construction, recombinant selection and screening, Analysis of expression, Analysis of recombinant DNA, site-directed mutagenesis, altered expression and engineering genes.DNA amplification using polymerase chain reaction, Key concepts, Analysis of amplified products, Applications of PCR; Ligase chain reaction. Expression systems and their applications, E.coli, Streptomyces, Yeast, Baculovirus and animal cells as cloning hosts, Sequencing methods. Transfection techniques, Gene silencing techniques, Gene knockouts and gene therapy, Differential gene expression and protein array, Protein-protein interactions, DNA-Protein interactions. Somatic and germ line therapy-in vivo and ex vivo, Transgenic. Applications of Genetic Engineering: Pharming, Genetically Engineered Foods, Biofuels, Designer Babies.

Practicals:

1. Designing and strategy of gene cloning
2. Restriction digestion
3. single double and partial digestion
4. Star activity
5. Agarose gel electrophoresis
6. Modification of DNA ends
7. PCR

Suggested Books:

1. RN Old,SB.Primrose, Principles of gene manipulation, Blackwell Scientific Publications, 1994
2. DM. Glover, BD. Hames,DNA cloning I & II, IRL Press, 1995
3. MA. Innis, DH.Gelfand , JJ. Sninskey ,PCR stratagies, Academic Press, 1995
4. D.Balasubramanian ,Concepts in Biotechnology – Editors, University Press ,1996.

BIO5404 **Systems Biology**

Systems Biology, Fundamentals: Overview of Gene Control, working of Genetic Switches, introductory systems. Biology The biochemical paradigm, genetic paradigm and the systems paradigm. Kinetics: Equilibrium Binding and Co-operativity, Michaelis-Menten Kinetics, identical and independent binding sites Identical and interacting binding sites, non-interacting binding sites. Genetic switch in Lambda Phage -Noise-based Switches and Amplifiers for Gene Expression. Gene Regulators. Synthetic genetic switches. Ecoli chemotaxis –biological oscillators- genetic oscillators -The Origin and Consequences of Noise in Biochemical Systems. Developmental Systems Biology, Building an Organism Starting From a Single Cell, Quorum Sensing, Programmed Population Control by Cell-Cell Communication and Regulated Killing, Drosophila Development. Establishment of Developmental Precision and Proportions in the Early Drosophila embryo. Gene expression networks, Gene regulation at a single cell level- Transcription Networks -basic concepts -coherent Feed Forward Loop (FFL) and delay gate -The incoherent FFL -Temporal order, Signaling networks and neuron circuits -Aspects of multi-stability in gene networks.

Practicals:

1. Gene and Protein data handling
2. Genome Database navigation
3. Alignment and phylogeny
4. Ortholog identification
5. Large scale domain analysis
6. Downloading and manipulating transcriptomes

7. Transcriptome metaFanalysis
8. CisF regulatory element search algorithms
9. Interactome analysis and protein interaction domains
10. Motif searching for key interaction sequences

Suggested Books

1. U Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits,Chapman & Hall/CRC Press , 2006.
2. Darren J Wilkinson, Stochastic Modelling for Systems Biology, CRC Press,2018

BIO5406 Web Application Development

Introduction to basic concepts of Servers, HTTP, HTTPS, FTP. Linux and HTML. Perl Programming Introduction and Installation Data types: Arithmetic and Logical operators,

Conditionals and Loops, List and Arrays, Working with files, Regular Expression and Pattern

Matching, Bio-perl installation and any two related modules. MySQL CGI and PHP, Installing MySQL, MySQL Programs, Working with Data, MySQL Privileges MySQL and Perl: Perl DBI, Connect, Statement Handles, Error Handling, Server Admin. Apache Understanding Apache, Installation, Configuration.

Practicals:

1. Brief Overview of Web servers, Web Browsers and Apache HTTP server.
2. Introduction to PERL?, requirements, Why PERL? Basic PERL syntax, tag, Comments
3. in PERL, variables, different operators (arithmetic, assignment, comparison, logical and
4. concatenation).
5. PERL Loops: while, do ... while, for, foreach
6. PERL form handling
7. PERL functions: Declaring functions, Adding parameters, Returning values.
8. PERL MySQL:Connect, Create, Insert, Select etc.

Suggested Books:

1. Adam McDaniel,Perl and Apache : Your visual blueprint for developing dynamic web content ,Wiley Publishing Inc., 2010
2. James Tisdall, Beginning Perl for Bioinformatics, O'Reilly Media, 2001.
3. Patrick Galbraith, Developing Web Applications with Apache, MySQL, memcatched and Perl, Wiley Publishing Inc., 2009

BIO5408 **Image Processing in Medicine**

Photography and film image: Principle of photography and radiographic film image, image quality factors (resolution, contrast, noise), Visual perception, structure and image formation in the eye, Introduction to digital image processing: Image acquisition and processing, uniform and Non-Uniform Sampling, Quantization, Image formats Image enhancement: Spatial Domain-Point processing techniques, histogram processing, Frequency Domain techniques- Basics of Fourier transform, 2D-DFT, Low pass and high pass filters, Noise removal, Homomorphic filters. Image Compression: Fundamentals of Image compression models, Techniques of Lossless and Lossy Compression. Basic principles of image segmentation and its transforms: Representation and description in image processing, special imaging techniques: Cineradiography, stereoscopic radiography, magnification radiography, microradiography, neutron radiography. Fluoroscopy and angiography, Digital subtraction angiography (DSA), Infrared Imaging and thermography. Introduction to computed tomography: Principle and configurations/generations, detectors, data acquisition system, spiral CT, scannerparameters, CT Number Reconstruction techniques, Radon Transform, Filtered Backprojection, Reconstruction techniques, Image quality and artifacts, Clinical applications of CT Multi-detector computed tomography (MDCT), CT-Angiography.Radiation therapy: Radiotherapy principles, dosage data for clinical applications (ISODOSE charts), radiation therapy planning, collimators and beam direction devices, dose measurement and treatment planning, teleisotope units, safety protocols & protection.

Suggested Books:

1. Gonzalez, Woods ,Digital Image Processing, - Pearson Education,2008
2. A.K. Jain ,Fundamentals of Digital Image Processing, Printice Hall Inc, 1989
3. C Majumder , Digital Image Processing and Analysis ,Printice Hall India,2011
4. Sonka, Hlavac,Boyle,Digital Image Processing and Computer Vision,Cenage learning,2008
5. William K. Pratt ,Digital Image Processing, John Wiley& Sons, Inc,2001

BIO5302 **Minor Project**

BIO5304 **Medical Bioinformatics**

An Overview- Introduction, Problems in health care motivating biomedical informatics, Seminal documents and reports, Resources of field - organizations, information, education. Biomedical Computing-Types of Computers, Data Storage in Computers, Computer Hardware and Software, Computer Networks, Software Engineering, Challenges for Biomedical Computing Electronic Health Records: Clinical Data and Workflow, History and Perspective of the Health (Medical) Record, Potential Benefits of the Electronic Health Record, Definitions and Key Attributes of the EHR, EHR Examples, Nursing Informatics Clinical Decision Support; EHR Implementation: Historical Perspectives and Approaches, Medical Errors and Patient Safety, Reminders and Alerts, Computerized Provider Order Entry (CPOE), Implementing the EHR, Use and Outcomes of the EHR, Cost-Benefit of the HER Secondary Use of Clinical Data: Personal Health Records, Health: Info. Exchange, Public Health, Health Care Quality, Clinical Research, Personal Health Records, Health Information Exchange, Public Health Informatics, Health Care Quality, Clinical Research Informatics Evidence-Based Medicine and Medical Decision Making: Definitions and Application of EBM, Interventions, Diagnosis, Harm and Prognosis, Summarizing Evidence, Putting Evidence into Practice, Limitations of EBM Information Retrieval and Digital Libraries: Information Retrieval, Knowledge-based Information, Content, Indexing, Retrieval, Evaluation, Digital Libraries Imaging Informatics and Telemedicine:

naging in Health Care, Modalities of Imaging, Digital Imaging, Telemedicine: Definitions and Barriers, Efficacy of Telemedicine.

Suggested Books:

1. J.van Bemmel , M.A. Musen , Mark Musen, Handbook of Medical Informatics,Springer-Verlag ,2002
2. Eta S. Berner, M. J. Ball , Clinical Decision Support Systems : Theory and Practice (Health Informatics),Springer-Verlag, New York Inc,1999

BIO5306 Pharmacoinformaics

Curriculum covers wide range of subjective description on the whole topic to provide well-covered knowledge on the subject. It includes following sub-divisions; Introduction and Classification of drugs which covers basic information on molecular descriptors, structural genomics and its approaches, efforts and its impact. To know about protein structural initiative and structural genomics consortium. Our target study of the subject includes; nucleus as target, coding and noncoding RNA, SNP analysis, molecular modelling and simulation in drug designing. Next module is based on pharmacokinetics and pharmacodynamics, including its introduction, compartment model study, pharmacokinetic parameters, absorption, distribution, metabolism, excretion, multiple doses, salt factor and bioavailability. Bioactive conformation of the molecules, crystallography, energy minimization and bioactive conformation. Pharmacodynamics includes drug receptor action, drug-drug interaction, polymorphism, and drug metabolism, Drug potency and efficacy, Receptor effector coupling, Spare receptors. Therapeutic index, Types of drug design, Structure-based, ligand based, fragment based, metabolites and their importance in drug design and pharmaco-informatics includes tools, cancer informatics, neuro-informatics and related case studies.

Suggested Books:

1. Hillisch, Alexander, Modern Methods of Drug Discovery, Birkhauser Verlag,2003
2. Makriyannis, Alexandros, Drug Discovery : Strategies and Methods,Wiley-VCH,1990
3. Edward D Zanders, Chemical Genomics and Proteomics , Humana Press,2012

BIO5308 Immunoinformatics

Immuno-informatics course begins with an overview of immune system, basic information relating antigen, antibodies, the complement system, Antigen-Antibody Reactions, The Major Histocompatibility Complex, allele selection, Antigen Presentation, TAP, T cell receptors followed by advance immunology which includes Immune Effector Mechanisms: Cytokines and Chemokines, Hypersensitive Reactions. The Immune system in Health and Disease: Autoimmunity, Transplantation Immunology, Classification of Vaccine. HLA system in model organism defining HLA Supertypes in: HLA–Structural and Modeling Principles, HLA Super types by GRID/CPCA and Hierarchical Clustering Methods, Structural Basis for HLA-A2 Supertypes, Clustering of MHC Peptide-Binding Repertoires, HLA Alleles-Electrostatic Distribution Maps. In-silico prediction of immunogenicity searching (IPD, IMGT, SYFPEITHI) predicting Peptide- MHC binding Profiles, Machine Learning Techniques for MHC Binders, Artificial Intelligence Methods for Predicting T-Cell Epitopes, MHC-Class I and II Binding Affinity. MHC– Molecular Affinity and QSAR Models, Support Vector Machine for MHC-Binding Peptides, Static Energy Analysis of MHC Class I and Class II Peptide-Binding Affinity, Nonlinear Predictive Modeling of MHC Class II–Peptide Binding Using Bayesian, Neural Networks.

Suggested Books:

1. Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne, Janis Kuby,Immunology,W.H. Freeman & Company, 2003.
2. Ivan M. Roitt, Peter J. Delves ,Roitt's Essential Immunology,Blackwell Science Ltd, 2001.
3. Darren R. Flower ,Immunoinformatics: predicting Immunogenicity in-silico Humana Press,2002

BIO5202 Open Air Seminar-II

BIO5204 Python programming for Bioinformatics

This course includes modules. First module provides general introduction on how to run python and its working environment. Second modules includes introduction to Strings, Lists, Tuples, Dictionaries, Numbers, Files. Syntax rules such as Indentation, Line Structure, Block structure, Special objects will be addressed in third module of this course. Conditionals, Loops-while loop, for loop, more about loops will be covered here in fourth module. Functions and exceptions will be explained in next two modules and final module includes introduction to biopython, BioSeq and BioSeqRecord Modules, Using Seq class, sequences reading and writing, BioSwissProtSProt and BioWWWExPASy, Regular expressions in Python, Running Blast and Clustalw.

Suggested Books:

1. M. L.Model ,Bioinformatics programming using python,Shroff Publishers,2010
2. S Bassi, Python for Biologists, CRC press,2009

BIO5206 Bioethics and IPR

Introduction to ethics and bioethics which includes ethical theories and ethical, legal and socio-economic aspects relating to use of genetic information, gene therapy, stem cell research, genetic engineering. Next section of this course introduces to biosafety issues in biotechnology, safety protocols, biosafety levels, biosafety guidelines and regulations; types of biosafety containment, Types of IPR, patents, copy rights, trade marks, importance of IPR, special application of Indian patent laws, PR in research. final section includes Stages of Clinical trials, protection of rights of subjects in clinical trial cohorts, challenges for the Pharmaceutical and Biotechnological industries and marketing of drugs; Case studies for discussing legal and socioeconomic impacts of biotechnology.

Suggested Books:

1. M. W. Martin,R.Schinzinger,Ethics in engineering, Tata McGraw- Hill,2003.
2. A. Sasson,Biotechnologies and Development, UNESCO Publications, 1988
3. A Biotechnologies in developing countries present and future, UNESCO Publishers, 1993

BIO5208 Perl Programming for Bioinformatics

Basic Linux & Command line, Introduction and rationale, Strings & Variables, lists and arrays, hashes, Control statements, Regular Expressions, Scope, functions & subroutines, Scope & packages, packages & Modules, Data structures & Computational complexity, Dynamic Programming & Sequence alignment, Object Oriented Programming.

Suggested Books.

1. J Tisdall ,Beginning Perl for bioinformatics, O'Reilly publishing, 2001

SEMESTER III

BIO651 Research Project

BIO601 Major Project-I

BIO6401 Drug Design and Discovery

This course explains the basics of drug discovery and high throughput screening systems followed by approached to new drug discovery which includes alternative strategies in lead identification, lead optimization, preclinical studies and development. This section comprises of concepts of receptor theory, lead compound discovery of receptor agonists and antagonists receptor complexes and allosteric modulators, pharmacophore-based ligand libraries, QSAR; peptido-mimetics; molecular mechanics, protein folding, docking, pharmacophore models, quantum mechanics in drug design. Last section includes Clinical trials, Patenting; New age drugs-synthetic vaccine design; personalized medicine.

Practicals:

1. To perform BLAST and Sequence Alignment.
2. To study Protein Structure and Families.
3. To perform Protein structure modelling (Homology Modelling).
4. To predict B cell linear and discontinuous epitopes in an antigen sequence.
5. To predict T cytotoxic cell epitopes in an antigen sequence.
6. To perform inhibitor studies
7. To study receptor ligand interaction by docking.
8. To predict protein three-dimensional structure.

Suggested Books:

1. C. Hansch, Comprehensive Medicinal Chemistry,Academic Press, 1990.
2. M. Sandler,H. J. Smith ,Design of Enzyme Inhibitors as Drugs,Oxford Univ. Press, 1989.
3. J. Matsoukas, T. Mavromoustakos, Drug Discovery and Design: Medical Aspects, IOS Press, 2002.
4. D R. Flower, Drug Design: Cutting Edge Approaches,The Royal Society of Chemistry, Cambridge, 2002.
5. R. A. Broglia, L. Serrano, Protein Folding and Drug Design, IOS Press, 2007.

BIO6403 Neurobiology

This course explains the fine structure of brain and its function further elaborating role of receptors, synapses and neurotransmitters. This course covers the basic understanding and knowledge of molecular and cellular neurobiology along with general description of neurodegenerative disorders

Alzheimer's disease, Huntington's disease, Poly Q disorders, Amyotrophic Lateral Sclerosis (ALS) Cross talk between neurons and muscles: Parkinson's disease, Inclusion body myositis (IBM), Polymyositis (PM). It also includes Neurotherapeutics and Neuroinformatics Action of bio molecules in neuroprotection, neuroprosthetics.

Practicals:

1. Morphology of Neurons
2. Structure of brain
3. Propagation and transfection in neuronal cell lines
4. Propagation and transfection in neuronal cell lines
5. Case Studies

Suggested Books:

1. Mark F Bear, Neuroscience, Lippincott Williams and Wilkins,2015
2. Mark F Bear, Barry W. Connors, Michael A. Paradiso,Neuroscience: Exploring the Brain, Lippincott Williams & Wilkins, 2006,
3. Duane E. Haines,Gregory A. Mihail, Fundamental Neuroscience for Basic and Clinical Applications, Elsevier,2017

BIO6405 Cell and Molecular Biology

This course begins with explaining the cellular architecture of prokaryotic and eukaryotic cell, extracellular matrix, cell junctions, cell cycle. Cell signaling and protein trafficking which includes mechanisms involved in cell-cell signaling, Long distance and short distance signaling, Intracellular signaling proteins, Secondary messengers, Protein targeting to various organelles, Vesicular trafficking will be explained here. This course also elaborates on mechanism and regulation of DNA replication, Transcription, Translation of DNA, causes of DNA damage and its mechanism of repair. Techniques used in molecular biology such as Agarose gel electrophoresis, Polyacrylamide gel electrophoresis, Polymerase Chain Reaction, DNA sequencing, Protein sequencing, Recombinant DNA technology, DNA fingerprinting and Oligonucleotide synthesis included in last section of this course.

Practicals:

1. Isolation of DNA and RNA
2. Plasmid DNA isolation
3. mRNA Purification
4. Electrophoresis
5. Quantification of DNA and RNA
6. Restriction Digestion
7. Mutation

Suggested Books:

1. D. Voet ,J.G. Voet ,Biochemistry,John Wiley & Sons, 2010
2. J.E. Kreb's et al,Lewin's Gene XI, Jones & Bartlett Learning, 2013
3. T.A. Brown ,Genomes , John Wiley and Sons Inc , 2003
4. Malacinski ,Essentials of Molecular Biology,Jones and Barlett Publ., 2005

BIO6407 Biostatistics

The course begins with the description of statistics and probability which includes central tendency and dispersion, Axiomatic concepts of Conditional probability. Multiplication rule of probability, The Baye's rule. The concept of random variables, distribution function and mathematical expectations of statistical parameters are explained in next section. Probability distributions which includes Binomial, Multinomial, Poisson and Exponential distribution will be addressed in this section. Correlation, regression and sampling distributions includes method of least square and curve fitting, Probable error, Regression, Statistics and sampling distributions come under this sections. Finally explaining significance of exact sampling distributions using Chi-square distribution test, Student's t-distribution test and Snedecor's F-distribution test.

Suggested Books:

1. M Pagano, K Gaureau, Principles of Biostatistics ,Thomson Learning, 2007.
2. S M Ross,Probability and Statistics for Engineers and Scientists,Academic Press, 2005.
3. R E Walpole, R H Myers, S L Myers, K Ye, Probability and Statistics for Engineers and Scientists ,Prentice Hall, Inc. 2002
4. H C Taneja,Statistical Method for Engineering and Sciences, IK International, 2009.

BIO6301 Nanotechnology in Health Care

This course comprises of five sections. First section discuss the basics of human anatomy, physiology and protein- and peptide-based compounds for cancer, diabetes, infectious diseases, organ transplant and therapeutic classes-focused pharmaceutical delivery systems. Second section elaborates on different immunoassay techniques such as antibody based method (ELISA), immune-sensors and Bio-Barcode assay for diagnostics for cancer and central nervous system disorders. Third section takes into account improved diagnostic products and techniques allows in vivo imaging enabling the detection of tumors, plaque, genetic defects and other disease states, ability to control or manipulate at atomic scale, Nano-bot medical devices, logic and intelligence embedded into medical devices, standalone sensing and computing devices. Fourth section includes new generations prosthetic and medical implants like artificial organs and implants, artificial scaffolds or biosynthetic coatings. Final section consists of methods for Diagnosis such as DNA profiling, cantilever sensors, targeted drug delivery, magnetic nanoparticles, Electrochemical Impedance Spectroscopy (EIS).

Suggested Books:

1. Brian, R Eggins ,Chemical Sensors and Biosensors,Wiley publication,2002
2. Ed. L Gorton ,Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry, Elsevier ,2005
3. Ed. David Wild ,The Immunoassay Handbook, Elsevier; 2005

BIO6303 Resource Planning and Management in Bioinformatics

Course includes Introduction to Fundamentals of Resource management practices. Which includes our to bioinformatics web sites, Biological databases and software an overview, Open source movement, Bioinformatics Resource utilization and commercialization, Networking and Super Computing resources- worldwide and India specific facilities, Clinical applications of bioinformatics. Bioinformatics resource management: the key-issues (piracy, hacking and data mining), Data Security and integration in Pharma Industry, tools and techniques. Bioinformatics Resources as a business practice: The bioinformatics market- Bioinformatics companies and products, commercialization of bioinformatics' resources, funding agencies for bioinformatics projects, models of technology transfer & licensing. Commercial & Financial aspects of Bioinformatics: Concepts of software product, Market and process economics Financial appraisal of bioinformatics projects cash flow, diagram, ROR, discounted ROR etc., Architecture of a typical bioinformatics business plan. TRIPS agreement: IPR issues in relation to software products/ processes; Architecture of Patent application, Biotechnology & Bioinformatics Related issues of Public Concern Bioethics.

Suggested Books:

1. A Leon, ERP Demystified, Tata McGraw Hill, 1999
2. Joseph A. Brady, Ellen F. Monk, Bret J. Wangner, Concepts in Enterprise Resource Planning, Thomson Learning, 2001
3. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007

BIO6305 Advanced Drug Delivery Systems

First section of this course includes introduction to dendrimers and methods use to synthesize dendrimers along with application and biocompatibility of dendrimers in gene transfection. Description of micro-fabricated drug delivery systems such as micro-needles, micro-pumps, micro-valves, implantable microchips covered in next section of this course along with the properties of each of these systems. Polymeric nano-systems, Liposomes and antibodies based delivery systems for site specific targeted delivery of drugs will be addressed in the next section of this course followed by the final section which includes virus based nanoparticles, its modification by bio-conjugation and describing the concepts of tumour targeting in-vivo and the use of biomedical imaging.

Suggested Books:

1. M. Salzman, Drug Delivery: Engineering Principles for Drug Therap,yOxford University Press, 2001
2. A.M. Hillery, Drug Delivery and Targeting, CRC Press, 2002
3. B. Wang, Drug Delivery: Principles and Applications, Wiley Intersceince, 2005

BIO6307 Artificial Intelligence

An Introduction to AI including the basic definition and motivation for computer assisted decision making, Knowledge representation- Production rules, Frames, Predicate calculus and Semantic nets, Knowledge acquisition, reasoning methodologies- Problem representation, Search, Dempster-shafer theory, Evaluation. Expert systems Basic concepts of Expert system, Structure of Expert system, Working, Types, Benefits, Problems and limitations of Expert system. Alternative approaches: Genetic algorithm- Genetic operators, Evolution strategies, Probabilistic systems- Bayesian approaches, parameter estimation, Discriminant analysis, regression analyser, Hybrid systems- Hybrid system

approaches, components of hybrid system, design methodologies, Pattern recognition- Statistical and Syntactic recognition.

Advanced intelligent systems: Objectives of neural network, Early models, Basic concepts, Classes of neural network, Learning – Supervised and unsupervised learning methods, Design, Validation and Evaluation.

Fuzzy systems in medicine: Fuzzy machine and signal processing – Unsupervised brain tumor segmentation using fuzzy techniques, Neuro-fuzzy knowledge processing, Neuro- fuzzy control and hardware in medical application.

Suggested Books:

1. Donna L. Hudson, Maurice E. Cohen ,Neural Networks and Artificial Intelligence for Biomedical Engineering, IEEE press, 2000
2. E. Turban, Jay E. Aronson,Decision Support Systems and Intelligent Systems, Prentice-Hall, 2001
3. Fuzzy and Neuro- Fuzzy systems in medicine edited by H.N Teodorescu, A. Kandel, L.C Jain, CRC Press, 1999.
4. Pattern Recognition for Medical Imaging, Anke Meyer-Base, Elsevier, Academic Press, 2004

BIO6201 Design and Analysis of Algorithms

Introduction to different algorithms and fundamentals of these algorithms in problem solving followed by analysis of algorithms including mathematical analysis of Non-recursive and Recursive algorithm such as Fibonacci Numbers, empirical analysis and visualization, analysis on algorithms would require various sort and search methods which includes Brute Force method, Selection Sort and Bubble Sort, Sequential Search and Brute-force string matching, Divide and conquer, Merge sort, Quick Sort, Binary Search, Binary tree, Traversal and Related Properties, Decrease and Conquer, Insertion Sort, Depth first Search and Breadth First Search. This course includes number of techniques and methods like Transform and conquer, Pre-sorting, Balanced Search trees, AVL Trees, Heaps and Heap sort, Dynamic Programming, Warshall's and Floyd's Algorithm, Optimal Binary Search trees, Greedy Techniques, Prim's Algorithm, Kruskal's Algorithm, Dijkstra's Algorithm, Huffman trees, Backtracking, n-Queen's Problem, Hamiltonian Circuit problem, Subset-Sum problem, Branch and bound, Assignment problem, Knapsack problem, Traveling salesman problem in order to design different algorithms.

Suggested Books:

1. D C Kozen,Design and analysis of algorithms ,Cornell , 1990
2. T H Corman,R L Rivest ,Introduction to algorithms ,PHI publications,2009
3. GS Baluja,Data structure through C : a practical approach, Dhanpat Rai & Co, 2012

BIO6203 Molecular Evolution

This course includes Changing concepts along with the theories and evidences of evolution of life forms on Earth followed by the forces responsible for evolution. These forces includes domestication, mutation, recombination, selection and speciation. Next section of this course focuses on role of genome duplications, transposable elements, noncoding RNAs and epigenetic mechanism in regulation of gene expression and genome evolution. Final section of this course includes the origin

and evolution of genes and proteins, changes in structures and functions along with the current approaches to study evolutions.

Suggested Books:

1. D Graur D, W H Li , Fundamentals of molecular Evolution, SINAUER ASSOCIATES, INC, Sunderland,1991
2. W H Li ,Molecular Evolution, SINAUER ASSOCIATES, INC,Sunderland, Massachusetts,1997
3. D Graur ,Molecular and Genome Evolution, Oxfrod University Press,2016
4. L Bromham L, An Introduction to Molecuar Evolutionand Phylogenetics, Oxford University Press,2015

BIO6205 Molecular and Cellular Biophysics

Basic concepts in atomic and molecular structures including brief introduction to molecular orbitals theories, types of bonds and interactions involved. Detailed study of nucleic acids (DNA,RNA), their types and structures, conformational parameters and geometries, rotational isomers, polymorphism and supercoiling, base pairing and stacking. Introduction to polypeptides (proteins and peptides) including properties of amino acids, titration curves of amino acids, principles behind ionization equilibria in proteins followed by structural studies of proteins in terms of structural level of proteins, forces stabilizing different levels, conformational structure, properties and transitions in biomolecules (alpha keratin, collagen, actin, conformation of globular proteins, haemoglobin , myoglobin). Structural analysis of cell membranes and ion channels covering components, properties (elastic, electrical, fluidic phase), organisation of lipids and proteins in membrane, electrostatic interaction and diffusion across membrane followed by molecular basis of ions channels together with their types, structure and role in transport.

Suggested Books:

1. E A Ackerman,Ellis, L.E.E. & L E Williams , Biophysical Science, Prentice-Hall Inc,1979
2. C Barrow, Physical Chemistry For Life Sciences, McGraw-Hill.1974
3. V A Bloomfield, R E Harrington , Biophysical chemistry, W.A.Freeman and co,1975
4. I A V Bulter,D E Noble, Progress in Biophysics and Molecular Biology (all volumes) pergamon, Oxford,1976

BIO6207 Entrepreneurship

Introduction to small scale industries including their types, characteristics, their role on national economy, Government policies and stages in starting these small scale industries. Identification of project for these small scale industries based on field studies, assess the viability of project, formulation methods and evaluation methods. Identification of project is followed by collection of information, preparation of project reports and balanced sheets, demand analysis, expected cost, planning and production control, sales and purchases, material balance and output methods and finally the project planning and control using financial functions cost of capital approach based on Economic evaluation, risk analysis, capital expenditures, policies and practices in public enterprises. Profit planning and programming, planning cash flow, capital expenditure and operations. control of financial flows, control and communication. Introduction to Laws concerning entrepreneurs, Partnership laws, business ownership laws , sales and income taxes and workman compensation act. Role of various national and state agencies which render assistance to small scale industries.

Suggested Books:

1. J Forbat, Entrepreneurship, New Age International,2008
2. Havinal, Veerbhadrappa, Management and Entrepreneurship,New Age International,2009
3. Joseph, L. Massod, Essential of Management, Prentice Hall of India,2000

Semester IV

BIO652 Research Project

BIO602 Major Project II

DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Bio Medical Engineering)

Programme Specific Outcomes

1. To utilize and enhance engineering and biological training to solve problems related to health and healthcare that are globally relevant and based on ethically sound principles.
2. Demonstrate leadership in their respective careers in biomedical engineering or interrelated areas of industry, government, academia, and clinical practices.
3. Engage in life-long learning by continuing their education in advanced career or professional training.
4. Design interdisciplinary approach towards biomedical problems.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN BIO MEDICAL ENGINEERING (BME)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

	Semester-I													
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	BME501	Human Anatomy and Physiology	Core	4	3	0	2	15	25	20	40	-	17
	2	BME503	Biomaterials and Clinical Devices	Core	4	3	0	2	15	25	20	40	-	
Group B	3	BME5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15/ 20	25/-	20 /30	40 /50	-	
	4	BME5301/5303/.....	Elective 2	Elective	3	3	0	0	20	0	30	50	-	
	5	BME5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	BME502	Tissue Engineering and Artificial Organs	Core	4	3	0	2	15	25	20	40	-	17
	2	BME504	Immuno-diagnostics and Therapeutics	Core	4	3	0	2	15	25	20	40	-	
Group D	3	BME5402/5404/.....	Elective 4	Elective	4	3/4	0	2/0	15 /20	25/-	20/ 30	40 /50	-	
	4	BME5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	BME5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	BME651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	BME601	Major Project I	Core	3						40	60		12
	2	BME6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15 /20	25/0	20 /30	40 /50	-	
	3	BME6301/6303/.....	Elective 8	Elective	3	3	0/ 1	2/0	15 /20	25/-	20 /30	40 /50	-	
	4	BME6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													
	1	BME652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	BME602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	BME5401	Medical Physics and Biochemistry	Elective	4	3	0	2	15	25	20	40	-
	2	BME5403	Instrumentation in Biomedical Engineering		4	4	0	0	20	-	30	50	-
	3	BME5405	Rehabilitation Engineering		4	4	0	0	20	-	30	50	-
	4	BME5407	Biopolymer Technology		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	BME5301	Nanobiotechnology & Nanomedicine	Elective	3	3	0	0	20	-	30	50	-
	2	BME5303	Infection and Disease		3	3	0	0	20	-	30	50	-
	3	BME5305	Molecular Basis of Metabolic Disorders		3	3	0	0	20	-	30	50	-
	4	BME5307	Pharmacology and Toxicology		3	3	0	0	20	-	30	50	-
	S.No.	Course Code		Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	BME5201	Open Area Seminar I		2	2	0	0		-	0	100	-
Elective 3	2	BME5203	Advanced Human Genetics	Elective	2	2	0	0	20	-	30	50	-
	3	BME5205	Protein Engineering		2	2	0	0	20	-	30	50	-
	4	BME5207	Biosensors		2	2	0	0	20	-	30	50	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	BME5402	Biophysical Signal and System Simulations	Elective	4	3	0	2	15	25	20	40	-
	2	BME5404	OMICS in Medicine		4	4	0	0	20	-	30	50	-
	3	BME5406	Image Processing in Medicine		4	4	0	0	20	-	30	50	-
	4	BME5408	Industrial Biotechnology		4	4	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	BME5302	Minor Project-1	Elective	3					40	0	0	60
	2	BME5304	Neurobiology		3	3	0	0	20	-	30	50	-
	3	BME5306	Oncology		3	3	0	0	20	-	30	50	-
	4	BME5308	Drug Design and Development		3	3	0	0	20		30	50	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	BME5202	Microarray Technology	Elective	2	2	0	0	20	-	30	50	-
	2	BME5204	Genetic Manipulation in Medicine		2	2	0	0	20	-	30	50	-
	3	BME5206	Hospital Management		2	2	0	0	20	-	30	50	-
	4	BME5208	Open Area Seminar II		2	2	0	0			0	100	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	BME6401	Bioinformatics	Elective	4	3	0	2	15	25	20	40	-
	2	BME6403	Biopharmaceuticals		4	4	0	0	20	-	30	50	-
	3	BME6405	Biostatistics		4	4	0	0	20	-	30	50	-
	4	BME6407	Molecular and Cellular Biophysics		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	BME6301	Bioethics and IPR	Elective	3	3	0	0	20	-	30	50	-
	2	BME6303	Population Genetics		3	3	0	0	20	-	30	50	-
	3	BME6305	Artificial Intelligence		3	3	0	0	20	-	30	50	-
	4	BME6307	Research Methodology		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	BME6201	Gene Therapy	Elective	2	2	0	0	20	-	30	50	-
	2	BME6203	Entrepreneurship		2	2	0	0	20	-	30	50	-
	3	BME6205	Biomechanics		2	2	0	0	20	-	30	50	-
	4	BME6207	Alternative Medicine		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

BME501 Human Anatomy and Physiology

Introduction of Structure and function of cell and cellular components; Membrane Potential; Overview of Immune system. Anatomy of physiological systems(I): Cardiovascular system; Nervous System; Nervous control of Heart. Anatomy of physiological systems(II): Musculo Skeletal System; Respiratory system; Regulation of Respiration; Artificial respiration. Overview of physiological systems:Gastro Urinal system, Urine Reflex; Skin and Sweat Gland – Temperature regulation. Physiological functions: Optics of Eye; Photochemistry of Vision; Accommodation Neurophysiology of Vision – EOG; Structure and functions Internal Ear - Mechanism of Hearing – Auditory pathway

Practicals:

1. Study of the human skull, forelimb and hind limb, pectoral and pelvic girdle, ribs
2. Study of the kidney, liver, brain with microscopic analysis
3. Microscopic staining techniques of various organs

Suggested Books:

1. A. C. Guyton, Textbook of Medical Physiology, Prism Book (p) Ltd. 1996.
2. C. L. Ghai, A textbook of Practical Physiology, 5th Edition. Jaypee Medical Publishers, 2003
3. S. Subramanyam, K. MadhavanKutty and H. D. Singh, Text book of Human Physiology. S. Chand & Company, 1996

BME503 Biomaterials and Clinical Devices

Introduction: Definition of biomaterial, history of biomaterial, requirements of biomaterials, classification of biomaterials, Comparison of properties of some common biomaterials. Classic examples of clinical use of biomaterial, Biological host responses to material. Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Host tissue reaction with metal, corrosion behavior and the importance of passive films. Hard tissue replacement implant: Orthopedic implants, Dental implants, Percutaneous implants, Soft tissue implant: vascular, facial and heart valve implants. Polymeric implant materials: Classification according to thermosets, thermoplastics and elastomers. Physiochemical characteristics of biopolymers. Ceramic and composite implant materials: Definition of bioceramics. Common types of bioceramics: Aluminium oxides, Glass ceramics, Carbons. Bioresorbable and bioactive ceramics.Toxicological screening and mechanical testing of biomaterials: Toxicity tests: acute and chronic toxicity studies (in situ implantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity tests.

Suggested Books:

1. J. D. Bronzino, The Biomedical Engineering Hand Book. Second Edition, CRC Press LLC. 2000
2. J.Y. Wong and J.D. Bronzino, Biomaterials, CRC Press, Taylor and Francis group. 2007.
3. B.D. Ratner, Biomaterials Science-An Introduction to Materials in Medicine, Third Edition. Elsevier press. 2013
4. J. Black, Biological Performance of Materials: Fundamentals of Biocompatibility, Fourth edition. CRC Press, Taylor and Francis group. 2005

BME5401 Medical Physics and Biochemistry

Functions of various cellular constituents: Action potential and its measurements, Hodgkin – Huxley model;Functioning of skeletal muscles; Blood and lymph circulation; Radioisotopes in biology and medicine; Safety handling of radioisotopes. Physics of the lungs and breathing: Physics of breathing mechanism, Surface tension and Laplace law; Airway resistance and determination; Measurement of lung Volumes, spirometer; Physics of some common lung diseases. Physics of the cardiovascular system: Major Components of the Cardiovascular System and its functioning; Physics of fluid movement, Bernoulli's Principle applied to cardiovascular system; Laminar and Turbulent Blood Flow. Biochemistry (I): Biomolecules; Carbohydrates, Structure and properties of mono, di, oligo and polysaccharides; Classification of lipids, phospholipids, steroids, essential fatty acids, prostaglandin. Biochemistry (II): Structure and properties of amino acids, titration curve, proteins, Ramachandran plot; Structure and properties of nucleic acids, denaturation and renaturation kinetics; Vitamins and minerals and associated disorders; Biochemical diagnostic tests and applications.

Practicals:

1. Qualitative estimation of carbohydrates by Molish test
2. Qualitative estimation of reducing sugars by Fehling solutions.
3. To determine presence of starch by Iodine test.
4. Qualitative estimation of aromatic amino acids by Xanthoproteic test
5. To detect the presence of Tyrosine by Millon's test
6. Detection of glycerol by Acrolein test for detection of
7. Estimation of total protein content by Lowry's method
8. To study Spirometer for lung volume measurement and its calculations
9. To study Electrocardiogram (ECG) and its analysis
10. To study Blood pressure measurement

Suggested Books:

1. J.R. Cameron and J.G. Skofronide, Medical Physics, Wiley publication; 1st edition (1978).
2. B.H. Brown, Medical Physics and Biomedical Engineering, IOP Publishing Ltd. (1999).
3. K. Elena, Basics of Medical Physics and Biophysics for electronic education of health professionals, Asklepios, Bratislava (2013).
4. D. L. Nelson and M. M. Cox, Lehninger's Principles of Biochemistry, Third Edition, Macmillan worth Publishers (2008).
5. D. Voet and J.G. Voet, Biochemistry, 4th ed. John Wiley & Sons(2010).

BME5403 Instrumentation in Biomedical Engineering

Clinical instrumentation: Centrifugation techniques, Analytical and Preparative centrifuges,Ultracentrifugation, pH: pH measurement, Microscope: Principle, parts, types and functioning of Microscope,Spectroscopy: UV, Visible, NIR, Spectrofluorometry, Atomic absorption spectrophotometry, Mass Spectrometry, Infrared and Raman Spectroscopy, Nuclear Magnetic Resonance and Electron Spin Resonance spectroscopy techniques. Electrophoretic and chromatographic techniques: Paper electrophoresis, Gel electrophoresis, Immunoelectrophoresis, Isoelectric focussing, Two-dimensional electrophoresis, Capillary electrophoresis; Paper chromatography, TLC,Gas chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC and FPLC. Basic concept of biomedical instrumentation: Electrodes, transducers, biosensors and their characteristics. Biopotential amplifiers. Biotelemetry. Recording of ECG, EEG, EMG,ERG. Cardiovascular measurements. Measurement of the respiratory system. Analytical instruments in biomedical engineering; oximeter, blood gas analyzer, blood cell counter. Therapeutic & assist devices for cardiovascular system and respiratory system.Physiotherapy devices. Electrosurgical units. Specialized therapeutic and diagnostic equipment: Cardiac pacemakers, heart lungmachines, Haemodialysis - design, clinical laboratory instrumentation, Audiometer, Phonocardiogram.

Suggested Books:

1. K. Wilson and J. Walker, Principles and Techniques of Practical Biochemistry, Cambridge University Press,2010
2. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry: The conformation of Biological Macromolecules. Publisher: W.H. Freeman, 1980.
3. J. G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2009
4. P. Narayanan, Essentials of Biophysics, Publishers: New Age International Publishers, 2000.
5. D.L. Pavia, G.M. Lampman and G. S. Kriz, Introduction to Spectroscopy. Publisher: Brooks Cole, 2009.
6. C. Tanford, Physical Chemistry of Macromolecules. Publisher: John Wiley and Sons Inc, 1961.
7. M. Kutz, Standard Handbook of Biomedical Engineering & Design, McGrawHill Publisher, UK,2003

BME5405 Rehabilitation Engineering

Introduction to rehabilitation: Rehabilitation acts and legislations, Key entities of Rehabilitation Engineering, Ergonomics: Work related disorders and their solutions, Assistive technologies devices, rehabilitation technology issues, Principles involved in the Assistive technology assessment, Misconceptions in field of assistive technology. Rehabilitation engineering concepts: Rehabilitation Engineering project design, Categories of assistive devices, Engineering concepts in sensory rehabilitation, Engineering concepts in motor rehabilitation, Rehabilitation in communication disorders. Orthopedic prosthetics andorthotics in rehabilitation technology: Upper limb prosthesis, lower limb prosthesis, Intelligent limb prosthesis, Problems in limb prosthesis, Functional Electrical Stimulation system. Sensory augmentation and substitution: Visual System: Visual augmentation, Tactual-Vision substitution, Auditory-Vision substitution; Auditory system: Auditory augmentation, Visual-Auditory substitution, Tactual-Auditory substitution; Tactual system:Tactual augmentation and substitution. Principles of application in rehabilitation engineering technology: Conceptual frameworks; The Provision Process; Education and quality assurance; Future development

Suggested Books:

1. J. D. Bronzino, The Biomedical Engineering Hand Book, Second Edition. CRC Press LLC. 2000.
2. T.Y. Kheng, Rehabilitation Engineering. InTech, Chapters. 2009
3. R.A Cooper, An Introduction to Rehabilitation Engineering, First Edition. CRC Press.2006
4. R.A Cooper, Rehabilitation Engineering Applied to Mobility and Manipulation, First Edition. CRC Press. 1995

BME5407 Biopolymer Technology

Introduction: Biopolymers produced from various renewable resources, characteristics, merits and demerits over conventional polymers. Biopolymer Technology and Applications: Biopolymers and Artificial Biopolymers in Biomedical Applications, an Overview. Biosynthesis and Modifications: Synthesis and modification of different Biopolymers like xanthum gum.Bioplastic: Different types of bioplastics; Applications of Bioplastics. Material Testing and Analytical Methods: An Overview of Available Testing Methods, Comparison of Test Systems for the examination of the Fermentability of Biodegradable Materials, Structure-Biodegradability Relationship of biopolymers.

Suggested Books:

1. E. Chiellini and H. Gil, Biorelated Polymers: Sustainable Polymer Science and Technology, Springer 2001.
2. R.M. Johnson, L.Y. Mwaikambo and N. Tucker, Biopolymers, Rapra Technology, 2003.
3. N. Kosaric (Ed), Biosurfactants. Marcell Dekker Inc, 1993

BME5301 Nanobiotechnology

Introduction to MEMS:Historical Background; Smart materials and structures-Microsystems and their advantages; General applications in aerospace, automotive industry and health care. Market size and world scenario. Micro machining technology: Lithography- etching- Ion implantation- wafer bonding- Integrated processing- Bulk micro machining- surface micro machining- coating technology and CVD-LIGA process. Principles of microsystems: General principles- Microsensors – Pressure sensors- Actuators- Electrostatic forces- Piezoelectric crystals – Intelligent materials and structures MEMS application in medicine (BioMEMS): Special features / requirements for medical applications. Current scenario of MEMS for health care. Drug delivery systems and MEMS. Application models – Blood pressure sensors – Biochip – Micro needles- Microelectrodes- Neural prosthesis and catheter end sensors. Biomedical nanotechnology: Nanotechnology and biomedicine- Medical applications of Nanotechnology- Drug synthesis and delivery- Nanobiomedicine and diagnostic – Nanofabrication methods – Nanomaterials in human body- Toxicity in nanomaterials.

Suggested Books:

1. M. Madau, Fundamentals of Microfabrication, CRC Press, 2002.
2. M.Gad-el-Hak, The MEMS Handbook, CRC Press, 2002.
3. T. R. Hsu, MEMS & Microsystem, Design and manufacture, McGraw Hill, 2002.
4. N. Malsch, Biomedical Nanotechnology, CRC Press, 2005.

BME5303 **Infection and Disease**

Immune pathogenic interactions: Host parasite interactions; Innate and acquired immunity, Toll like receptors; first line of defence; T cell and B cell mediated immune response. Parasitology: Virulence factors in parasites; basis for pathogenesis and molecular mechanisms in parasites. Drug resistance: Mechanism of drug resistance in different parasites. Diagnostics: Immunological diagnostic techniques - Immunodiffusion, Immuno-electrophoresis, ELISA, RIA, fluorescence activated cell sorter. Therapeutics: Vaccines; Hybridoma technology; Antibody engineering, synthetic antibodies; Immunity to parasites and therapeutics.

Suggested Books:

1. C. Janeway, P. Travers, M. Walport and M.J. Shlomchik, Immunobiology, Garland Science, New York. (2001)
2. R. A. Goldsby, T. J. Kindt, B.A. Osborne and J. Kuby; Immunology , 5th edition; W.H. Freeman & Company, Pages 19-504, 2003.
3. I. M. Roitt and P. J. Delves, Roitt's Essential Immunology , 10th Edition; Blackwell Science Ltd., 2001.

BME5305 **Molecular Basis of Metabolic Disorders**

Introduction: metabolic pathways, Carbohydrate metabolism and disorders. Lipids: metabolism and disorders. Proteins: metabolism and disorders. Hormones: hormonal disorders, diagnosis/detection of metabolic disorders. Molecular approaches: Genetics, genomics and epigenomics of metabolic disorders.

Suggested Books:

1. G. F. Hoffmann, Z. Johannes and L.N. William, Inherited Metabolic Diseases: a clinical approach, Springer-Verlag Berlin Heidelberg (2017)
2. E. G. Barness, L.A. Barness and P.M. Farrell, Metabolic diseases, second edition, IOS Press (2017)
3. J.M. Saudubray, G.V. Berghe and J.H. Walter, Inborn Metabolic Diseases: diagnosis and treatment, Springer-Verlag Berlin Heidelberg(2012)

BME5307 **Pharmacology and Toxicology**

Principles of Toxicology, Mechanisms of Toxicity, Toxicokinetics: Routes of Administration, Absorption, Distribution, and Excretion. Toxicodynamics- Receptors, Bonds, Dose Response, Membrane Structure and Transport, Biotransformation of Xenobiotics: Biotransformation/Metabolism-Phase I and Phase II reactions. Toxicological studies on organ-Toxicology of the Liver, kidney, Lung Neurotoxicology, Cardiovascular Toxicology, Intestine, Skin Chemical Carcinogenesis & Genetic Toxicology. Molecular Toxicology- Toxicogenomics, Immunotoxicology, Toxic Effects of Pesticides Reproductive Toxicology & Teratology. Toxicology of Metals, Nanotoxicology, Ecotoxicology, Analytical/Forensic Toxicology, Risk Assessment; Case studies on Toxicology, Epidemiological studies.

Suggested Books:

1. C.D. Klaassen, Casarett and Doull's Toxicology-The Basic Science of Poisons, 6th Edition. New York: McGraw-Hill, 2001
2. J. Timbrell, Introduction to Toxicology, 3rd edition, 2001.

3. B. Levine, Principles of Forensic Toxicology, 2nd edition (revised & updated), 2003

4. C.D. Klaassen, JB Watkins III, Essentials of Toxicology. New York: McGraw-Hill, 2003.

5. E. Hodgson, A Textbook Of Modern Toxicology, John Wiley & Sons, Inc., Publication, 2004

6. W. Brutting, Physics of Organic Semiconductors, Wiley-VCH Verlag Gmbh & Co. KGaA, Germany. 2005

BME5201 Open Area Seminar I

BME5203 Advanced Human Genetics

Induction: Basic concepts in genetics, history genetic diseases, inheritance of single and polygenic disorders in human; autosomal, sex linked, sex limited and sex influenced traits. Molecular basis genetic disorders: common and rare genetic disorders, chromosomal aberrations and mutations. Approaches to identify genetic disorders: Identification and detection of genetic loci causing common and rare genetic disease, linkage and linkage disequilibrium mapping, genomewide association studies, genome sequencing. Epigenetics in genetic disorders: Role of epigenetics in human genetic disorders: mechanism, changes in phenotypes and inheritance. Risk assessments/ predictions: Calculation/predictions of risk of inheritance of genetic diseases, treatment of genetic diseases and ethical considerations

Suggested Books:

1. K. Ikehara, Advances in the study of Genetic Disorders, IntechOpen Limited, The Sharad, 25thFllor, 32 London Bridge Street, London, SE19SG-United Kingdom, 2011

2. M. Levitan, Text book of Human Genetics, Third edition, Oxford University Press, Oxford, U.K. 1988

3. A. Gardner and T. Davies , Human Genetics, Scion Pub., 2009

4. A. Lewish , Human Genetics: Concepts and Applications, 4th Edition, McGraw-Hill, 2001

5. A. Al-Chalabi and L. Almasy, Genetics of Complex Human Diseases: A Laboratory Manual Cold Spring Harbor Laboratory Press, U.S, 2009

BME5205 Protein Engineering

Bonds and Energies in protein: Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure. Amino acids and their characteristics: Amino acids- structure with three and single letter codes, molecular properties, Chemical reactivity. Protein architecture: Primary structure, Secondary structure, Tertiary structure, peptide sequencing. Structure-function relationship: DNA binding proteins- Prokaryotic transcription factors, Eukaryotic transcription factors, Membrane proteins. Identification and analysis of proteins: Identification and analysis of proteins by 2D analysis, Mass spectrometry.

Suggested Books:

1. P.C.E. Moody and A.J. Wilkinson , Protein Engineering, IRL Press, Oxford, UK. 1990

2. C Branden and J Tooze, Introduction to Protein Structured, Second Edition, Garland Publishing, NY, USA. 1999

3. T.E. Creighton, Proteins, Freeman WH, Second Edition. 1993

4. J. P Sheldon and R.C Jennifer, Protein Engineering and Design, CRC Press. 2009

5. S Lutz and U. T. Bornscheuer, Protein Engineering Handbook, Volume 1 & Volume 2, Wiley publication, 2011

BME5207 Biosensors

Introduction: Biosensors–definition, types and components, biologically active material and analytes as bioreceptors, Types of membranes used in biosensor constructions, Immobilization of bioreceptors, transducers in biosensors and their types, applications and uses of Biosensors, advantages and limitations. Functions of biological sensors: Sensors/receptors in the human body, chemoreceptors: hot and cold receptors, baroreceptors, sensors for smell, sound, vision, osmolarity and taste. Transducers: Electrochemical Transducers, three-electrode system, Reference electrodes, redox systems and mediators for biosensors, electrochemical techniques for biosensing, optical transducers. Types of biosensors: Enzyme electrode, glucose sensors, immunosensors, DNA-based biosensors, optical biosensors, optical fiber sensors, and indicator mediated transducers, surface plasmon resonance, Biosensors based on Evanescent Waves. Applications: Nanomaterials based biosensors, Microfabricated Sensors and the Commercial Development of the I-Stat-Point-of-Care system, Biosensors for personal diabetes management, Non-invasive Biosensors in Clinical Analysis, Biosensors in environmental monitoring, Introduction to Biochips and their application in modern sciences, Bimolecular electronics.

Suggested Books:

1. B.D. Malhotra and C.M. Pandey, "Biosensors: Fundamentals and Application," Smithers Rapra, UK, 2017.

2. B.D. Malhotra and Md. A. Ali, "Nanomaterials for Biosensors: Fundamentals and Applications," Elsevier Inc, 2017.

3. J. Wang, "Analytical Electrochemistry," Wiley-VCH, 1994.

4. A.V.S. De Renck, "Touch Heat & Pain", Churchill Ltd. London.

5. D. L. Wise, "Applied Biosensors", Butterworth, London, 1989.

6. J.G. Webster, Encyclopedia of Medical Devices and Instrumentation Vol I,II,III,IV (PHPub), 2006.

SEMESTER II

BME502 Tissue Engineering and Artificial Organs

Historical perspective and introduction: Historical perspective of tissue engineering industry and products; Cell and Tissue Biology: Introduction to basic biology concepts; Stem cells and its applications. Scaffolds for tissue engineering: Classification of scaffold materials, criteria for ideal scaffold, control of architecture; Design and Clinical Implementation. Design of artificial organs: Substitutive medicine, Biomaterial Concentration, Outlook for Organ Replacement, Design Consideration, Evaluation of Artificial Organs. Artificial Heart and Circulatory Assist Devices.Artificial organ studies: Artificial lungs; Artificial kidney; Artificial pancreas; Artificial blood; Artificial liver. Case studies: Comparison of Artificial Lungs and Natural Lungs, Insulin therapy.

Practicals:

1. Recording of blood pressure using sphygmomanometer and stethoscope
2. Cardiac Efficiency Test
3. Mechanical Stimulation of the eye, Near point and Near response
4. Tuning Fork tests for Hearing
5. To sterilize the materials required for various cell culture practices.
6. To prepare desired growth medium for the given Animal cell culture.
7. Primary Cell Culture To perform primary cell culture technique using chick embryo under aseptic condition.
8. To develop secondary growth or established cells line (Balb3T3).
9. Subculturing of established cells line (Balb3T3).
10. To ensure the population of cells required for the culture works by cell counting method and its viability by vital staining methods
11. To preserve the cells in viable condition for future works by using proper preservative
12. To check cell viability and cell proliferation by MTT assay

Suggested Books:

1. L. L. Hench and J R Jones, Biomaterials, artificial organs and Tissue engineering, Wood head Publishing Ltd, 2005.
2. R P. Lanza, R L William and L. Chick Principle of Tissue Engineering, Academic Press, 2004.
3. Palsson and Bhatia, Tissue Engineering, Pearson Prentice Hall, 2004.
4. J.D. Bronzino, Tissue Engineering and Artificial Organs, CRC Taylor and Francis, 2007.
5. S.M. HollenBerg, Cardiogenic Shock, 2001.
6. G.E. Miller, Artificial Organs Morgan & Claypool Publishers, 2006.

BME504 Immuno- Diagnostics and Therapeutics

Introduction: Innate and acquired immunity, clonal nature of immune response, Concepts in Immunology: Antigens, Antibodies, Antigen-Antibody Reactions.Regulation of immune response: Antigen processing and presentation, generation of humoral immune responses, Cell mediated immune response; cytokines and their role in immune regulation. Cell-mediated toxicity: Mechanism of T-cell and NK-cell mediated lysis, antibody dependent cell mediated toxicity, cytotoxicity and macrophage mediated cytotoxicity, complement activation. Immune disorders: Mechanisms and failures in self-tolerance; complexity of immune disorders, Common autoimmune disease models. Immunology diagnostics and therapeutics: Immunological diagnostic techniques - Immuno diffusion; immunoelectrophoresis, ELISA, RIA, fluorescence activated cell sorter; Vaccines; Hybridoma technology; Antibody engineering, synthetic antibodies; Immunity to tumors

Practicals:

1. To study antigen antibody interaction by single immunodiffusion
2. To study antigen antibody interaction by double immunodiffusion
3. To study agglutination reactions
4. To perform dot blot techniques
5. Learn ELISA technique by direct and sandwich ELISA
6. Flowcytometry and its various applications
7. Differential count of white blood cells
8. Therapeutic applications in drug design and biomedical application

Suggested Books:

1. C. Janeway, P. Travers, M. Walport and M. J. Shlomchik, Immunobiology, Publisher: Garland Science, New York. (2001)
2. R.A. Goldsby, T.J. Kindt, B. A. Osborne and J Kuby; Immunology; W.H. Freeman & Company, 5th edition, Pages 19-504, 2003.
3. I. M. Roitt and P. J. Delves, Roitt's Essential Immunology; Blackwell Science Ltd., 10th Edition, 2001.
4. T.J. Kindt, B.A. Osborne and R.A. Goldsby, Kuby Immunology. Publisher: W.H. Freeman. (2006)

BME5402 Biophysical System and Signal Simulations

Introduction to continuous and discrete time signal and system: Signal energy and power, Transformation of independent variable, Types of signals. System Properties. Fourieranalysis: For continuous and discrete time process,Fourier transform analysis, C.T.F.Tand D.T.F.T.System .Time frequency and Wavelet analysis. Signal to noise analysis: Need for time frequency analysis for biomedical signal analysis, Introduction to tools: i) S.T.F.T ii) Wavelet. Introduction to Biomedical Signals - Event related potentials- Biomedical Signal Analysis- Estimationof Noise in Signals: Noise bandwidth, Noise factor, Noise factor in an amplifier and cascade amplifier. Feedback system: Basic Feedback concept, Positive and Negative Feedback, Sensitivity analysis, Effect of Feedback on disturbance or Noise, Distortion analysis by FeedBack, Control system-Open loop Control System-Control system With Feed Back. Modeling of physiological system block diagram: Modeling of Nerve action potential: Hodgkin-Huxley model, Modeling of Skeletal Muscle Contraction: Modeling of Myo electric activity. Modeling of cardiovascular system.

Practicals:

1. Demonstration of different signals and their properties.
2. To identify a given system as linear or non-linear, casual – Non causal.
3. Noise removal from the raw signal using Filters (High pas, low pass and Band Pass)
4. To visualize the relationship between the continuous-time Fourier series and Fourier transform of a signal.
5. To transform time domain signals to frequency domain signals
6. Wavelet analysis of different signals -1D wavelet.

Suggested Books:

1. Oppenheim, A Wilskey and S Nawab- "Signal & System", Prentice Hall India, 1983.
2. Hayken & VanVeen- "Signal & System", Willey, 2007.
3. A. Anand Kumar, "Signals and systems", PHI learning Pvt. Ltd., 3rd edition, 2015.
4. Taub & Schilling-"Principles of Communication System", Tata McGraw Hill, 1970.
5. Kennedy & Devis-"Electronic Communication System", Tata McGraw Hill, 1970.
6. Gayakward-"Opamps and Linear Integrated Circuits", Prentice Hall India, 1993.

BME5404 OMICS in Medicine

Introduction: Omics concepts and applications, sequencing of Human and other organisms. Metagenomics of infectious diseases: Role of Genomics in identification of microbes causing infectious diseases (microbiomes study), molecular epidemiology, host resistance to infection, pathogenicity, combating infectious diseases. Detection of genetic disorders: Genomics in detection of genetic disorders and treatment, pharmacogenomics. Epigenomics and non-coding RNAs: Role of Epigenomics and non-coding RNAs in disease development, inheritance and control. Translational and clinical trials: Genomics in translational and clinical trials, and risk assessments/prediction of genetic diseases with few successful case studies.

Suggested Books:

1. T. Strachan and A.P. Read, Garland Human Molecular Genetics, Third Edition, Science Publication, (2003).
2. H. Lodish, A. Berk, and C.A. Kaiser, Molecular Cell Biology, Sixth Edition, W. H. Freeman & Co Ltd, (2007).
3. V. J. Dzau and C. Chin Liew, Cardiovascular Genetics and Genomics for the Cardiologist, Blackwell Publishing, (2007).
4. C. R. Cantor and C. L. Smith, Genomics: The Science of Technology Behind the Human Genome Project, John Wiley & Sons, Inc, (1999).
5. M. Keynes, A.W.F. Edwards and R. Peel, A Century of Mendelism in Human Genetics, CRC Press, (2005).
6. T. Strachan , J. Goodship, P. Chinnery, Genetics and Genomics in Medicine, Garland Science, first edition, Garland Science, New York, U.S.A, (2014) .
7. S. T. Sonis, Genomics, personalized medicine and oral disease(2015) First edition, Springer publisher, 2015.

BME5406 Image Processing in Medicine

Photography and film image: Principle of photography and radiographic film image, image quality factors (resolution, contrast, noise), Visual perception, structure and image formation in the eye, Introduction to digital image processing: Image acquisition and processing, uniform and Non-Uniform Sampling, Quantization, Image formats. Image enhancement: Spatial Domain-Point processing techniques, histogram processing, Frequency Domain techniques- Basics of Fourier transform, 2D-DFT, Low pass and high pass filters, Noise removal, Homomorphic filters. Image Compression. Basic principles of image segmentation and its transforms: Representation and description in image

processing, special imaging techniques: Cineradiography, stereoscopic radiography, magnification radiography, microradiography, neutron radiography. Introduction to computed tomography: Principle and configurations/generations, detectors, data acquisition system, spiral CT, scannerparameters, CT Number Reconstruction techniques, Radon Transform, Filtered Backprojection, Radiation therapy: Radiotherapy principles, dosage data for clinical applications (ISODOSE charts), radiation therapy planning, collimators and beam direction devices, dose measurement and treatment planning, teleisotope units, safety protocols & protection.

Suggested Books:

1. R. Gonzalez and E. Woods, Digital Image Processing, Pearson Education, 2009.
2. A.K. Jain, Fundamentals of Digital Image Processing, P.H.I., 1989.
3. C. Majumder, Digital Image Processing and Analysis, Printice Hall India, 2011.
4. Sonka, Hlavac and Boyle, Digital Image Processing and Computer Vision, Cenage learning.
5. W. Pratt, Digital Image Processing, John Wiley & Sons, 2007.
6. Dowsett, Kenny & Johnston, "The Physics of Diagnostic Imaging", Chapman & Hall Medical, 2006.
7. Massey & Meredith, "Fundamental Physics of Radiology", John Wright & Sons, 1977.
8. S. Webb, "The Physics of Medical Imaging", Ada m Hilger, Bristol.
9. S.M. Stockley, "A Manual of Radiographic Equipments", Churchill Livingstones, 1986.
10. T. S. Curry, J. E. Dowdey and R. C. murry,Chistrmis, "Physics of Diagnostic Radiology", Lippincott Williams & Wilkins, 1990.

BME5408 Industrial Biotechnology

Introduction to industrial bioprocess: Fermentation, Basic concepts of Upstream and Downstream processes. Production of primary metabolites: Organic acids, Amino acids and alcohols. Production of secondary metabolites: Antibiotics, Vitamins and Steroids. Production of enzymes and other bioproducts: Production of Industrial Enzymes, Biopesticides, Biofertilizers, SCP & Mushroom cultivation. Bioseparation technologies: Solid liquid separation and other DSP steps.

Suggested Books:

1. Casida, Industrial Microbiology. Publisher: New Age International (2003).
2. W. Crueger and A. Crueger, Biotechnology. A Textbook of Industrial Microbiology (1990).
3. M.L. Shuler and F. Kargi, Bioprocess Engineering Basic Concepts, Publisher: Prentice Hall (1987).
4. J.E. Baily and D.F. Ollis, Biochemical Engineering Fundamentals. Publisher: McGraw Hill 2nd edition (1986).
5. R.O. Jenkins, Product Recovery in Bioprocess Technology, BIOTOL Series. Publisher: Butterworth Heinmann (1992).

BME5302 Minor Project-1

BME5304 Neurobiology

Introduction: Fine structure of the brain and its function, synapses, receptors and neurotransmitters. Basic neuroscience: molecular and cellular neurobiology and basic knowledge of general neurobiology. Neurodegenerative disorders: General description, Alzheimer's disease, Huntington's disease, Poly Q disorders, Amyotrophic Lateral Sclerosis (ALS). Cross talk between neurons and muscles: Parkinson's disease, Inclusion body myositis (IBM), Polymyositis (PM). Neurotherapeutics and neuroinformatics: Action of bio molecules in neuroprotection, neuroprosthetics.

Suggested Books:

1. B. F. Mark, B.W. Connors, and M.A. Paradiso, Neuroscience: Exploring the Brain, 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins, 2006. ISBN: 9780781760034
2. D. E. Haines PhD FAAAS FAAA (Author) and G. A. Mihailoff PhD Fundamental Neuroscience for Basic and Clinical Applications, Elsevier, 1998.
3. B F. Mark., Neuroscience , Publisher: Lippincott Williams and Wilkins, ISBN: 9780781778176, 0781778174, Pages: 1008, 2015.

BME5306 Oncology

Gene expression and DNA repair in eukaryotes: Mechanisms of DNA replication, transcription and translation, Telomerase, DNA repair mechanisms. Cell communication and signaling:Cell-cell interactions, Cell junctions, Communicating junctions, Adhesion junctions, Occluding junctions, Cell adhesion molecules, Extracellular matrix, Cell to cell signaling. Cell cycle and apoptosis: Processes and regulation of cell cycle, apoptosis, mitosis and meiosis. Molecular genetics of cancer: General concepts, Normal vs cancer cells, Tumor viruses, Metastasis, Angiogenesis, Genetic pathways in cancer, Roles of oncogenes and tumor suppressor genes in cancer, Regulation by p53 andpRb. Cancer therapy:Diagnosis, Molecularly targeted therapies of cancer, Cancer stem cells.

Suggested Books:

1. B. Alberts, Molecular Biology of the Cell. 6th ed. Garland Science, 2015
2. G. Karp, Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons, Inc., 2002
3. H. Lodish, Molecular Cell Biology. 7th ed. W.H. Freeman and Company, 2012
4. B. Alberts, Essential Cell Biology. Garland Publishing, 2009
5. R.A. Weinberg, The Biology of Cancer, 2nd ed. Garland Science, 2013
6. R. Lanza, Essentials of Stem Cell Biology. 2nd ed. Elsevier Academic Press, 2009

BME5308 Drug Design and Development

Drug discovery: Organized Drug discovery and development; drug delivery systems and high throughput screening systems. Approaches to new drug discovery: Alternative strategies in Lead identification, Lead optimization. Preclinical development. drug metabolism. Enzymes as targets of drug design: Enzyme kinetics, Enzyme inhibition and activation, Approaches to the Rational Design of Enzyme Inhibitors Structures of enzyme, Enzyme inhibition and activation, Approaches to the Rational Design of Enzyme Inhibitors. Receptors as targets of drug design: Receptor Theory, Lead Compound Discovery of Receptor agonists and antagonists Receptor Complexes and Allosteric

Modulators, Pharmacophore-based Ligand Libraries, QSAR; peptido-mimetics; Molecular Mechanics, Protein Folding, Docking, Pharmacophore Models, Quantum Mechanics in Drug Design. Drug design regulations: Clinical trials, Patenting; New age drugs-synthetic vaccine design; personalized medicine.

Suggested Books:

1. C. Hansch (Ed.); Comprehensive Medicinal Chemistry, (Vols. I-VI) Academic Press, 1990.
2. M. Sandler and H.J. Smith; Design of Enzyme Inhibitors as Drugs, Oxford Univ. Press, 1989.
3. J. Matsoukas and T. Mavromoustakos, Drug Discovery and Design: Medical Aspects, IOS Press, 2002.
4. D.R. Flower, Drug Design: Cutting Edge Approaches, The Royal Society of Chemistry, Cambridge, 2002.
5. R.A. Broglia and L. Serrano, Protein Folding and Drug Design, IOS Press, 2007.

BME5202 Microarray Technology

Introduction:Types of microarray, cDNA microarray, oligonucleotide microarray, spotted microarray, In situ synthesized microarray, Hybridization process, DNA microarray database. In situ synthesized microarray: Method of manufacturing, Phosphoramidite method. Spotted microarray: Method of manufacturing, Photolithography. Data acquisition and chip image analysis:Image segmentation, Intensity measurement, Normalization of data, Clustering analysis, Coexpression analysis. Applications of microarray technology: Differential gene expression analysis, Expression profiling, Genome sequencing, Copy number variation, Alternative splicing detection, Mutation analysis.

Suggested Books:

1. H. Causton, J. Quackenbush and A. Brazma, Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide. Publisher: Blackwell, 2003
2. D.P. Berrar, W. Dubitzky and M. Granzow, A Practical Approach to Microarray Data Analysis. Publisher: Springer, 2003
3. S. Drăghici, Data Analysis Tools for DNA Microarrays. Publisher: Chapman and Hall/CRC, 2003
4. F. E. Streib and M. Dehmer, Analysis of Microarray Data: A Network-Based Approach. Publisher: Wiley-VCH Verlag GmbH & Co., 2008

BME5204 Genetic Manipulation in Medicine

Transgenic technology:Vectors, Methods of transformation, Gene silencing, Co-suppression, Antisense RNA, RNAi, dsRNA-mediated DNA methylation, dsRNA mediated RNA degradation. Cell nuclear replacement: Stem cells, Somatic cell nuclear transfer, Embryo transfer technique, Embryo splitting, Therapeutic cloning, Reproductive cloning. Gene and genome editing:Site-specific integration, Random integration, Knock outs, Knock downs, Recombinases, Zinc Finger Nucleases, CRISPR/Cas 9, Transcription activator-like effector nuclease. Applications in medical and health sectors: Applications of transgenic microbes, plants and animals in medicine, Recent advancements. Regulations: Biosafety guidelines, National regulatory mechanism, Public perception

Suggested Books:

1. T.A. Brown, Gene Cloning & DNA Analysis: An Introduction. Blackwell Publisher, 2001
2. Primrose & Twyman, Principles of Gene Manipulation & Genomics. Seventh edition, 2006
3. J. Sambrook and D.W. Russel, Molecular Cloning: A Laboratory Manual. Third edition Publisher: Cold Spring Harbor Laboratory Press, 2001
4. B.R. Glick and J.J. Pasternak, Molecular Biotechnology: Principles and Applications of Recombinant DNA. Publisher: ASM Press, 2003
5. S. Rastogi and N. Pathak, Genetic Engineering. Publisher: Oxford University Press, 2009

BME5206 Hospital Management

Organisation and planning of the hospital: Organisational structure: Governance, Duties and responsibilities of the governing board, Management structure: Duties, responsibilities and functions of the CEO, Hospital information System: Benefits, Organisation, Layout, Survey, Financial planning, Equipment planning. Medical and auxiliary services: Emergency services, Clinical laboratories, Radiological services, Diagnostic radiology, Radiation therapy department, Nuclear Medicine, Surgical Department, Physical Medicine and Rehabilitation, CATH lab, OT: Design and related equipments. Nursing services: General nursing unit, Central Nurse Station, Paediatric nursing unit, Isolation rooms, Intensive Care Unit(ICU), Coronary Care Unit(CCU), Newborn nurseries. Hospital services: Electrical system, Air conditioning services, Centralised gas system, Communication systems, Transportation, Biomedical Engineering department: Functions, Designs, Space facilities, Utilities. Safety and security in the hospital: Hospital safety rules, Security and loss prevention, Fire safety, Bomb threat, Alarm systems, Disaster and Disaster preparedness plan, Safety codes for electrical and medical equipments, Medical standards for hospitals and equipments.

Suggested Books:

1. G.B. Kunder and Gopinath, "Hospital Planning, Design and Management", Tata McGraw Hill, 2000.
2. S.L. Goel and R. Kumar, "Principles of Hospital Administration and Planning", Deep and Deep Publications, 2007.
3. B. Feinberg, "Applied Clinical Engineering", Prentice Hall, 1986.
4. J. Webster and A. Cook, "Clinical Engineering Principles and Practices", Prentice Hall, 1979.
5. H.D. Banta and B. Luce, "Health Care Technology and its Assessment", Oxford Medical Publications, 1993.
6. B.M. Sakarkar, "Principles of Hospital Administration and Planning", Jaypee Publications, 2004.

SEMESTER III

BME6401 Bioinformatics

Biological databases: Types, Overview of Biological Databases and Retrieve; Nucleic acid databases: NCBI; Protein Databases- Primary, Functional, Composite, Secondary, Ensembl; Sequence Formats & storage, Sequence submission to sequence database.

Computational genomics: Structure of DNA, Polymorphisms in DNA Sequence, Human Genome

Project, Complete Genome Sequences, Functional Annotation. Database searching: Local alignment, Global alignment, Scoring matrices- PAM, BLOSUM, Gaps, Dot Plots. Dynamic programming Approach: Needleman and Wunsch Algorithm, Smith and waterman Algorithm, Heuristic Approach: BLAST, FASTA. Multiple sequence alignment: global and local alignments, scoring matrices and gap penalties, filtering, position specific scoring matrices, internet resources, uses of multiple. Sequence alignment, programs and methods for multiple sequence alignment, representation, structural inference. Soft computation: Machine learning, support vector machines, Neural Networks, Fuzzy logic, genetic algorithms - applications to bioinformatics.

Practicals:

1. Inter-conversion different sequence file format
2. Database Searching using Entrez and SRS
3. Study of Databases and Data retrieval
4. Dot Matrix Alignments
5. Needleman Wunsch Alignments.
6. Smith Waterman Alignments
7. Multiple Sequence Alignment & Phylogenetic Tree
8. Understanding machine learning using weka

Suggested Books:

1. A.M. Lesk; Introduction to Bioinformatics; Oxford University Press, 2003
2. D.W. Mount, Sequence and Genome Analysis, Cold Spring Harbor Laboratory, 1st edition; 2004.
3. A.D. Baxevanis and B.F.F Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley-Interscience, 3rd Edition, 2004

BME6403 Biopharmaceuticals

Introduction to pharmaceuticals: History, sources of drugs, Routes of drug administration,Drug metabolism, Prodrug and soft drugs; Physico-chemical parameters in drug design; QSAR; Active site determination of enzymes; Design of enzyme inhibitors.

Pharmacokinetics and pharmacodynamics: Biotransformation of drugs, mechanism of drug action, drug receptors, Preclinical Pharmacokinetics; Assay systems and models (e.g., Knock-out Mice). Pharmaceutical dosage forms: Dosage Forms and Basic Preparations, Clinical Trials, packaging techniques – quality control. Pharmaceutical products and products of DNA technology: Microbial products - Antibiotics, vitamins, probiotics;Plant secondary metabolites;Pharmaceutical products of DNAtechnology. Drug safety evaluationand patenting process in drug manufacturing process: Regulation of Human Pharmaceutical Safety, Toxicity Testing in Drug Safety Evaluation, Immunotoxicology in Pharmaceutical Development, Pharmaceutical Quality Assurance, Patenting-Patent types, The patent application, Patenting in biotechnology, The role of regulatory authorities.

Suggested Books:

1. H. Klefenz, Industrial pharmaceutical biotechnology, John Wiley sons, 2002.
2. S. Wu-Pong, Y. Rojanasakul, and J. Robinson, Biopharmaceutical drug and design and development, Humana Press, 2007.
3. G. Walsh, Biopharmaceuticals: Biochemistry and Biotechnology (2e), John Wiley & Sons, 2003.
4. H.A. Kirst, W.K. Yeh and J. Milton , Enzyme Technologies for pharmaceutical and biotechnological applications, WILEY-VCH Verlag, 2003

BME6405 Biostatistics

Descriptive Statistics & Probability: Measure of central tendency and dispersion, Axiomatic concepts; Conditional probability. Multiplication rule of probability. Baye's rule. Random variable and expectation: Random variable and distribution function. Mathematical expectation. Statistical parameters. Chebyshev's inequality. Probability distributions: Binomial, Multinomial, Poisson and Exponential distribution. Correlation, regression and sampling distributions: Method of least square and curve fitting, Probable error, Regression, Statistics and sampling distributions, Tests of significance. Exact sampling distributions and small sample test: The Chi-square distribution. Student's t-distribution. Snedecor's F-distribution.

Suggested Books:

1. M. Pagano and K. Gaureau, Principles of Biostatistics,7th ed., Publisher: Thomson Learning, (2007).
2. S.M. Ross, Probability and Statistics for Engineers and Scientists, 3rd ed. Publisher: Academic Press, (2005).
3. R.E. Walpole, R.H. Myers, S.L. Myers and K Ye, Probability and Statistics for Engineers and Scientists. Publisher: Prentice Hall, Inc. (2002)
4. H.C. Taneja, Statistical Method for Engineering and Sciences Publisher: IK International, (2009).

BME6407 Molecular and Cellular Biophysics

Basic concepts: atomic and molecular structure, molecular orbital theories, Secondary bonding: weak interactions, hydrogen bonding; dipole-dipole & dipole-induced dipole interactions, Molecular structures: conformation parameters of nucleic acids, nucleic acid geometrics, glycosidic bond rotational isomers, DNA polymorphism and supercoiling, base pairing and stacking, Types & structure of RNA, m RNA, tRNA, rRNA & modified nucleotides, tertiary structure of nucleic acids. Proteins: properties of amino acids , equilibria in proteins, structural levels of proteins & stabilizing forces, conformational properties of polypeptides, Ramchandran plot, Helical parameters & conformation, conformational structures of alpha keratin, collagen, actin, conformation of globular proteins, hemoglobin , myoglobin, etc., β bends & bulges, super secondary structures, Domain & motifs, Cell Membranes and Ion channels: Components of cell membrane, electrical properties of cell membrane, membrane organization & stability; Molecular motion in membrane & membrane fluidity, Protein lipid interactions. Electrostatic interaction between membrane surfaces, simple diffusion & facilitated diffusion, diffusion of nonelectrolytes across the membrane, Molecular basis of aqueous channels, osmotic pressure and equilibrium, Ion channel structure and gating function, Ion channel types and characterization, Role of carriers in ion transport, cellular thermodynamics.

Suggested Books:

1. A.E.A. Ellis, L.E.E. & L.E. Williams, Biophysical Science, Prentice-Hall Inc (1979).
2. C. Barrow, Physical Chemistry For Life Sciences, McGraw-Hill(1974).
3. V.A. Bloomfield and R.E. Harrington, Biophysical chemistry, W.A. Freeman and CO(1975).
4. A.V. Bulterl And D. Noble, Progress in Biophysics and Molecular Biology (all volumes) pergamon, Oxford(1976).

Elective 8

BME6301 Bioethics and IPR

Introduction to ethics and bioethics: Ethical theories; Biotechnology and ethics;ethical aspects relating to use of genetic information, genetic engineering and bio-warfare. Ethical implications of cloning: Reproductive cloning, therapeutic cloning; Ethical, legal and socio-economic aspects of gene therapy, stem cell research; ELSI of human genome project. Introduction to biosafety and containment:Biosafety issues in biotechnology; safety protocols, biosafety levels, biosafety guidelines and regulations; types of biosafety containment. Introduction to intellectual property rights: Types of IPR: patents, copy rights, trade marks; importance of IPR, special application of Indian patent laws; IPR in research. Ethics related to clinical trials: Stages of Clinical trials, protection of rights of subjects in clinical trial cohorts, challenges for the Pharmaceutical and Biotechnological industries and marketing of drugs; Case studies for discussing legal and socioeconomic impacts of biotechnology.

Suggested Books:

1. M.W. Martin and R. Schinzinger, Ethics in Engineering, III Edition, Tata McGraw- Hill, New Delhi. 2003.
2. P. J. Atkins, Biotechnologies and Development, UNESCO Publications, 1988
3. A Biotechnologies in developing countries present and future, UNESCO Publishers, 1993
4. K. Singh, Intellectual property rights on Biotechnology, BCIL, New Delhi, 2014.
5. V. Krishna, Bioethics and biosafety in Biotechnology, New Age International Publishers, 2007

BME6303 Population Genetics

Introduction: Population Genetics, Genetic and Phenotypic Variation, mutations and their effect. Population structure: The Hardy-Weinberg Equilibrium, random and non random matting population, effective population size, factors affecting HW equilibrium. Molecular basis of genetic and phenotypic variations: Measuring genetic variation in natural population, understanding the molecular basis of within and between population diversity, population structure, linkage disequilibrium Selection and Mutations. Genetics of evolution: Molecular basis of phenotypic evolution in populations, rate of molecular evolution, synonymous and non synonymous substitutions, mapping and understating of evolution of quantitative traits variations in natural populations. Population genomic and proteomics: Human Population Genetics, Analysis of complex diseases using Genome-Wide Association studies, population structure and demographic history. Epigenetics in populations: role of epialleles and epigenetic mechanism in variation and inheritance in phenotypic traits in populations.

Suggested Books:

1. S Freeman and J C. Hendon, Evolutionary Analysis, Fourth Edition, Pearson Education. Molecular Genetic Analysis of Populations and Hoelzel, 2nd Edition, Oxford University, 1998.
2. Hartl and Jones, Genetics -Principles and Analysis 5th edition Jones and Barlet, 2001.
3. P.W. Hedrick, Genetics of Populations, 2nd Edition, Jones & Bartlett 2000
4. Hartl& Clark, Principles of Population Genetics, 3rd Edition, Sinauer Associates Inc. 1997

BME6305 Artificial Intelligence

Artificial intelligence: Definition, Motivation for computer assisted decision making, Knowledge representation- Production rules, Frames, Predicate calculus and Semantic nets, Knowledge acquisition, reasoning methodologies- Problem representation, Search, Dempster-shafer theory, Evaluation. Expert systems:Basic concepts of Expert system, Structure of Expert system, Working, Types, Benefits, Problems and limitations of Expert system. Alternative approaches: Genetic algorithm- Genetic operators, Evolution strategies, Probabilistic systems- Bayesian approaches, parameter estimation, Discriminant analysis, regression analyser, Hybrid systems- Hybrid system approaches, components of hybrid system, design methodologies, Pattern recognition- Statistical and Syntactic recognition. Advanced intelligent systems:Objectives of neural network, Early models, Basic concepts, Classes of neural network, Learning – Supervised and unsupervised learning methods, Design, Validation and Evaluation. Fuzzy systems in medicine:Fuzzy machine and signal processing – Unsupervised brain tumor segmentation using fuzzy techniques, Neuro-fuzzy knowledge processing, Neuro- fuzzy control and hardware in medical application.

Suggested Books:

1. D. L. Hudson and M. E. Cohen, Neural Networks and Artificial Intelligence for Biomedical Engineering, IEEE press, 2000.
2. A.M. Base and Elsevier, Pattern Recognition for Medical Imaging, Academic Press, 2004.
3. H.N. Teodorescu, A. Kandel and L.C. Jain, Fuzzy and Neuro- Fuzzy systems in medicine, CRC Press, 1999.
4. E. Turban and J E. Aronson, Decision Support Systems and Intelligent Systems, 6th edition, Prentice-Hall, 2001.

BME6307 Research Methodology

Phenomena, Scientific proofs and conjunctions Research concept, Basis and nature of inquiry and research, types, scientific research, falsification and critical thinking. Introduction to research, need, ethics, research plan, literature review, citation, plagiarism, report structure and writing. Hypothesis, modeling, data collection, test of hypothesis, validation. Literature review- longitudinal and thematic. Nature of data-primary, secondary, techniques of measurement and scaling, sampling methods, sample result. Collection of data-research questionnaire-types of questions, questionnaire design, survey methods. Research design-Exploratory, experimental, causal, analytical, empirical, case research.

Suggested Books:

1. W.J. Goode and P.K. Hatt: Methods in social research. McGraw-Hill New York, (1982).
2. C.R. Kothari, Research methodology: Methods & Techniques, New Age International. New Delhi(2006).
3. M. Roig, Avoiding plagiarism, self-plagiarism, and other questionable writing practices: A guide to ethical writing, (2006)
4. L. Vaughan, Statistical methods for the information professional: A practical, painless approach to understanding, using and interpreting statistics (Ed. 2), Information Today, Medord(2004).
5. I. Willemese, Statistical methods and calculation skills (Ed. 3), Juta. Cape Town(2009).

BME6201 Gene Therapy

Introduction: Somatic and germline gene therapy, Gene replacement and gene addition, ex vivo and in vivo gene therapy, Applications, Genetic disorders. Gene silencing and transgenics: Vector based gene therapy, siRNA technology, Micro RNA, Transgenics, Gene and genome editing. Gene knockouts: Creation of knockout mice, Disease model, Gene tagging, T-DNA and transposon tagging, Homologous recombination. Gene analysis: cDNA arrays, Intragenic arrays, Differential gene expression analysis, Protein array. Gene therapy and diseases: Case studies, Drug designing, Clinical trials of gene therapeutics, Regulation.

Suggested Books:

1. J. Niewöhner and C. Tannert , Gene Therapy: Prospective Technology Assessment in its Societal Context. Publisher: Elsevier B.V., 2006
2. M. Giacca, Gene Therapy. Publisher: Springer Science, 2010
3. S. Rastogi and N. Pathak, Genetic Engineering. Publisher: Oxford University Press, 2009
4. S.S. Stober and D. Yarri, God, Science, and Designer Genes: An Exploration of Emerging Genetic Technologies. Publisher: Praeger, 2009
5. R.W. Herzog and S.Zolotukhin, Guide to Human Gene Therapy. Publisher: World Scientific Publishing Company, 2010

BME6203 Entrepreneurship

Introduction: Definition. growth of small-scale industries; role of small scale industries in the national economy; characteristics and types of small scale industries; Government policy for small scale industry; stages in starting a small scale industry. Project identification: Assessment of viability, formulation, evaluation, financing, field-study and collection of information, preparation of project report, demand analysis, material balance and output methods, benefit cost analysis. Accountancy: Preparation of balance sheets and assessment of economic viability, decision making, expected costs, planning and production control, quality control, marketing, industrial relations, sales and purchases. Project planning and control: The financial functions, cost of capital approach in project planning and control. Economic evaluation, risk analysis, capital expenditures, policies and practices in public enterprises.capital expenditure and operations. control of financial flows, control and communication. Laws concerning entrepreneur: Partnership laws, business ownership, sales and income taxes and workman compensation acts.

Suggested Books:

1. Forbat, John, "Entrepreneurship" New Age International, 2008.
2. Havinal, Veerbhadrappa, "Management and Entrepreneurship" New Age International, 2009.
3. J. L. Massie, "Essential of Management", Prentice Hall of India, 1971.

BME6205 Biomechanics

Introduction: Fundamentals of mechanics, torsion, bending, stress transformation, thermodynamics. Mechanics in Physiology: Applications of mechanics in physiology. Mechanical properties of biomaterials: Mechanical properties of bones, cartilage. Physiological application of Mechanics: Muscle movements, forces and mechanics, Current Research topics; IPR and patents.

Reference Books:

1. R. Hibbeler, Mechanics of Materials, 10th edition, ISBN 9780134321240, 1985.
2. D. Knudson, Fundamentals of Biomechanics, Springer Publication; ISBN 978-0-387-49312-1, 2003.
3. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007

BME6207 Alternative Medicine

AYUSH: medical systems practiced in India such as Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homeopathy, The basic approach of all these systems on health, disease and treatment. Mental Health Disorder and Psychotherapy: different types of mental health disorders and treatment, including hospitalization, inpatient, outpatient, and psychotherapy. Physiotherapy and Supportive care: Physiotherapy in palliative care, supportive care in treatment of disease, and psychological, social, and spiritual problems related to a disease or its treatment. Naturopathy and Nutrition: Yoga, types of Yoga and its relevance, Meditation, Diet and Nutrition. Health awareness and Public Health Systems.

Suggested Books:

1. L. Emmerton, J. Fejzic, & S.E. Tett, Consumers' experiences and values in conventional and alternative medicine paradigms: A problem detection study (PDS). BMC Complementary and Alternative Medicine, 12(1), 39. doi:http://dx.doi.org/10.1186/1472-6882-12-39, (2012).
2. W. Jonas, Advising patients on the use of complementary and alternative medicine. Applied Psychophysiological Biofeedback, 26(3), 205-214., (2001).

Semester IV

BME652 Research Project

BME602 Major Project II

DEPARTMENT OF BIOTECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Industrial Biotechnology)

Programme Specific Outcomes

1. Aaquire fundamental knowledge of biotechnology for sound and solid base which enables them to understand the emerging and advanced engineering concepts in life sciences.
2. Demonstrate practical and theoretical knowledge essential for pursuing higher studies.
3. Biotechnology industry oriented preparednes-Demonstrate an ability to identify careers in biotechnology domain like Pharmaceutical, Food Industry, Agriculture, Environmental Biotechnology based industries etc.
4. Recognize the importance of Bioethics, IPR, bioentrepreneurship, Communication and management skills so as to prepare next generation of India Industialists.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN INDUSTRIAL BIOTECHNOLOGY (IBT)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	IBT501	Bioenergy	Core	4	3	0	2	15	25	20	40	-	17
	2	IBT503	Industrial Plant Biotech-nology	Core	4	3	0	2	15	25	20	40	-	
Group B	3	IBT5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15 /20	25/0	20 /30	40 /50	-	
	4	IBT5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	IBT5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	IBT502	Functional Genomics and Proteomics	Core	4	4	0	0	20	0	30	50	-	17
	2	IBT504	Bioprocess Engineering and Reactor Design	Core	4	3	0	2	15	25	20	40	-	
Group D	3	IBT5402/5404/.....	Elective 4	Elective	4	3/4	0	2/0	15 /20	25/0	20 /30	40 /50	-	
	4	IBT5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	IBT5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	IBT651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	IBT601	Major Project I	Core	3						40	60		12
	2	IBT6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15 /20	25/0	20 /30	40 /50	-	
	3	IBT6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	IBT6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group F	1	IBT652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	IBT602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	IBT5401	Bioinstrumentation	Elective	4	3	0	2	15	25	20	40	-
	2	IBT5403	Bioseparation Technology		4	4	0	0	20	-	30	50	-
	3	IBT5405	Nutraceuticals and Functional Foods		4	4	0	0	20	-	30	50	-
	4	IBT5407	Recombinant DNA Technology		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	IBT5301	Industrial Microbiology and Fermentation Technology	Elective	3	3	0	0	20	-	30	50	-
	2	IBT5303	Food Engineering & Biotechnology		3	3	0	0	20	-	30	50	-
	3	IBT5305	Green Energy		3	3	0	0	20	-	30	50	-
	4	IBT5307	Medical Biotechnology and Health Care		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	IBT5201	Open Area Seminar	Elective	2	2	0	0	0	-	0	100	-
Elective 3	2	IBT5203	Algal Biotechnology		2	2	0	0	20	-	30	50	-
	3	IBT5205	Applied Molecular biology and Genetic Engineering		2	2	0	0	20	-	30	50	-
	4	IBT5207	Nutritional Biochemistry		2	0	0	2	-	100	-	-	2
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	IBT5402	Advanced Environmental Biotechnology	Elective	4	3	0	2	15	25	20	40	-
	2	IBT5404	Biopolymer Technology		4	4	0	0	20	-	30	50	-
	3	IBT5406	Quality Management		4	4	0	0	20	-	30	50	-
	4	IBT5408	Plant Molecular Farming		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	IBT5302	Minor Project	Elective	3	3	0	0	0	40	0	0	60
	2	IBT5304	Biochemical Thermodynamics		3	3	0	0	20	-	30	50	-
	3	IBT5306	Transport Phenomenon		3	3	0	0	20	-	30	50	-
	4	IBT5308	Biopharmaceuticals		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	IBT5202	Nanobiotechnology	Elective	2	2	0	0	20	-	30	50	-
	2	IBT5204	Biosensor Technology		2	2	0	0	20	-	30	50	-
	3	IBT5206	Advanced Computational Genomics		2	2	0	0	20	-	30	50	-
	4	IBT5208	Food Microbiology		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	IBT6401	Enzyme Technology and Industrial Applications	Elective	4	3	0	2	15	25	20	40	-
	2	IBT6403	Metabolic Engineering.		4	4	0	0	20	-	30	50	-
	3	IBT6405	Vaccine Technology		4	4	0	0	20	-	30	50	-
	4	IBT6407	Advanced Biochemistry		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	IBT6301	Industrial waste water treatment	Elective	3	3	0	0	20	-	30	50	-
	2	IBT6303	Metagenomics		3	3	0	0	20	-	30	50	-
	3	IBT6305	Transgenic Technology		3	3	0	0	20	-	30	50	-
	4	IBT6307	Biomaterials		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	IBT6201	Bioethics, Biosafety and IPR	Elective	2	2	0	0	20	-	30	50	-
	2	IBT6203	Bioprocess Plant Design		2	2	0	0	20	-	30	50	-
	3	IBT6205	Advanced Animal Biotechnology		2	2	0	0	20	-	30	50	-
	4	IBT6207	Microbial Biotechnology		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

IBT501 Bioenergy

Global and Indian energy scenario, Description of various biofuels and its production, Process Technology for bioethanol production using Sugar, Starch and Lignocellulosic. Unit Operations in Alcohol production, Alcohol distillation, Lipids as a source of biodiesel, Methods of Biodiesel Production – General procedure and large scale production; Quality Control Aspects. Biodiesel production from microalgae and future prospects, Biohydrogen production by anaerobic bacteria and photosynthetic algae, Factors affecting biohydrogen production, Concept of Applied Bioenergy and its advancements with other sources of energy, Recent trends in bioenergy research. Relationship of Applied Bioenergy to Economy, Sustainable development, and environmental policies. Lab-Measurement of current from battery devices, Production of bioethanol from fruit wastes/sugarcane/ corn feedstock, Detoxification of Jatropha seed-cake by different methods, Production of Biodiesel from plant sources, Biodiesel/Biogas set-up, Estimation of catalytic activities of enzymes responsible for biohydrogen production.

Suggested Books:

1. F. Dalena , A. Basile and C. Rossi , Bioenergy systems for the future , Woodhead Publishing Series in Energy,2017
2. A. Pandey , J.S Chang , P. Hallenbeck and C. Larroche , Biohydrogen, Elsevier,2013
3. R. Ray and S. Ramachandran , Bioethanol production from Food crops: Sustainable Sources, Interventions and Challenges, Academic Press, 2018

IBT503 Industrial Plant Biotechnology

Micropropagation, Types of culture, haploid production, Somaclonal variation, Germplasm storage, Formation of Secondary Metabolites in Tissue Culture, Production of industrially important pharmaceuticals, Bioreactor system, Gene cloning, tools of genetic engineering, Vector and vectorless gene transfer, Herbicide resistance, biotic stresses and abiotic stresses resistance, transgenics plants as bioreactors, Production of industrial enzymes, bioplastics, edible vaccines, Introduction to Plant Bioinformatics, biological databases, Protein and Gene Information Resources, Plant specific Genomic Data.

Lab- Aseptic culture techniques for the establishment and maintenance of cultures, Preparation of plant tissue culture media, Establishment of shoot culture, In-vitro hardening technique for Tissue culture raised plants, To establish root suspension culture, To establish cell suspension culture, Studying the economic factors influencing micropropagation, Introduction to plant specific databases

Suggested Books:

1. R.A Dixon and R.A Gonzales, Plant Cell Culture: A Practical Approach, IRL Press, 1995.
2. K. Lindsey and M.G.K. Jones, Plant Biotechnology in Agriculture, Prentice Hall, New Jersey, 1990.
3. T.A Brown, Gene cloning & DNA Analysis: An introduction ,Wiley, 2001

IBT5401 Bioinstrumentation

Analytical, Preparative and ultra centrifugation, Paper and gel electrophoresis, Immuno electrophoresis, isoelectric focussing, two-dimensional electrophoresis, capillary electrophoresis, Paper, TLC, GC, HPLC, FPLC, gel filtration, ion exchange and affinity chromatography, UV-visible and NIR, spectrofluorimetry, Atomic absorption spectrophotometry, Mass Spectrometry, Infrared and Raman Spectroscopy, Nuclear Magnetic Resonance and Electron Spin Resonance spectroscopy, Principle, parts, types and functioning of Microscope, Optical and Electron Microscopy, Transmission and Scanning Electron Microscopy, Tunneling Electron Microscopy, Atomic Force Microscopy, Fluorescence microscopy, Confocal microscopy.Lab-Preparation of different types of buffers, Protein quantification, Protein separation through electrophoresis, Sample preparation for light microscopy and Electron Microscopy, Quantification of DNA and RNA, Quantification of Fatty acids and amino acids, Quantification of secondary metabolites of medicinal plants.

Suggested Books:

1. K. Wilson and J. Walker, Principles and Techniques of Practical Biochemistry, Cambridge University Press, 2002.
2. C.R. Cantor and P.R Schimmel, Biophysical Chemistry: The Conformation of Biological Macromolecules ,W.H. Freeman,1980.
3. P. Narayanan, Essentials of Biophysics, New Age Internationals, 2007.

IBT5403 Bioseparation Technology

Problems and requirements of bioproduct purification. Economics and downstream processing in biotechnology, physicochemical basis of bioseparation processes, Cell disruption methods, biomass separation techniques, flocculation and sedimentation, centrifugation precipitation and filtration methods, Batch extractions, staged extractions-cross current, co current, counter current extractions. Differential extractions, fractional extractions, supercritical fluid extraction, in-situ product removal/ integrated bioprocessing, Design & configuration of membrane separation equipment, reverse osmosis, dialysis, electro dialysis, isoelectric focusing, Adsorption isotherms, industrial adsorbents, adsorption equipments for batch and continuous operations (co current and counter current), adsorption in fixed beds, Principles of chromatographic separation– gel filtration, reversed phase, hydrophobic interaction, ion-exchange, affinity and IMAC.

Suggested Books:

1. P.A Belter, E. Cussler and W. Hu, Bioseparation – Downstream Processing for Biotechnology, Wiley Interscience, 1988.
2. Asenjo and J.A. Asenjo, Separation Processes in Biotechnology, CRC Press, 1990.
3. P.C Wankat, Rate Controlled Separation, Kluwer Publishers, 1990.

IBT5405 Nutraceuticals and functional Foods

Introduction to Nutraceuticals, Nutraceuticals bridging gap between food and drug, Nutraceuticals in treatment for cognitive decline, Nutraceutical remedies for common disorders like Bronchitis, circulatory problems, hypoglycaemia, Types of inhibitors present in various foods and how they can be inactivated. General idea about role of Probiotics and Prebiotics, Relation of functional foods & Nutraceutical, Applications of herbs to functional foods. Concept of free radicals and antioxidants; Nutritive and Non-nutritive food components with potential health effects, Sources and

role of Isoprenoids, Isoflavones, Flavonoids, carotenoids, Tocotrienols, polyunsaturated fatty acids, sphingolipids, lecithin

Suggested Books:

1. R.E Aluko, Functional Foods and Nutraceuticals, Springer, 2012.
2. S.K Brar, S. Kaur and G.S Dhillon, Nutraceuticals Functional Foods, Nova Science Publishers,2014.
3. R.E.C Wildman, Handbook of Nutraceuticals and Functional Foods, Third Edition,Wallace, 2002.

IBT5407 Recombinant DNA Technology

Plasmids and bacteriophages, cloning vectors for E.coli ; pBR322, pUC vectors, M13 and other plasmid vectors, Cosmids, Phagemids, vectors for Bacillus, Streptomyces Restriction mapping and analysis, DNA modifying enzymes, ligases, Nucleic acid probe preparation, Radioactive and nonradioactive labels, Hybridization techniques, PCR and its types, Expression vectors in prokaryotes, Expression vectors in Eukaryotes, Yeast cloning vectors, selectable markers for eukaryotes, SV40, Papilloma, Retrovirus, Baculoviral vectors, mammalian cell expression system – Gene transfer techniques, Preparation of rDNA, Preparation of cDNA and genomic DNA libraries – screening procedures – linkers, adapters, homopolymer tailing and TA cloning – gene transfer technologies – Mutagenesis – site directed mutagenesis – application, Fusion protein- down-stream processing of recombinant proteins- Applications in medicine – Gene therapy- Diagnostics.

Suggested Books:

1. J.W Dale, M. Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology-3rd Edition,Wiley-Blackwell, 2011.
2. M.R Green and J.Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition),Cold Spring Harbor Press,2012.
3. S.B Primrose and R.Twyman, Principles of Gene Manipulation and Genomics,Wiley,2009.

IBT5301 Industrial Microbiology and Fermentation Technology

Media components and optimization, types of culture media, Isolation, screening, Selection of mutants, Development of inoculums for industrial fermentation/ seed fermenter, Production of primary metabolites - Ethanol from molasses, acetone-butanol, citric acid, amino acids, Baker's yeast, polysaccharides and peptides and plastics, Production of secondary metabolites - Penicillin, Cephalosporins, Streptomycin etc., from microbial cell culture, Thermal death kinetics of microorganisms, batch and continuous heat sterilization of liquid media, air sterilization, Microbial growth kinetics, logistic growth model, growth of filamentous organism, Parts of fermenter, Oxygen uptake in cell culture, Oxygen transfer in fermenter, gas hold up, Measurement of KLa, factors effecting KLa in fermenter, Requirements for control, sensors, controllers, design of fermenter control specification.

Suggested books

1. Presott& Dunn's Industrial Microbiology, CBS Publishers,1987.
2. P. Stanbury, A. Whitaker and S. Hall, Principles of Fermentation Technology, Butterworth-Heinemann, 2nd Ed, 1999.
3. E.M.T El-Mansi and C.F.A Bryce, Fermentation Microbiology and Biotechnology, CRC Press, 3rd Ed, 2011.

IBT5303 Food Engineering and Biotechnology

Composition of foods and function of water, carbohydrates, proteins, amino acids, lipids, vitamins and shelf life of food, Nutritive value of foods, significance of microorganisms in foods. Biotechnological improvements, Microbial growth pattern. Biochemical changes caused by micro-organisms, deterioration of various types of food product, Dairy products: Production of starter cultures; Cheese - principles of cheese making. Cheddar Cheese, Swiss Cheese, Mold ripened Cheeses. Fermented foods, General principles underlying spoilage and chemical changes of food caused by microorganisms, food spoiling enzymes. Food preservation, Packaging and canning of foods, thermal processing of foods: Microwave heating, thermal inactivation of microorganisms, evaluations, freezing and thawing of foods, Basic principles, unit operations, and equipment involved in the commercially important food processing methods and unit operations; materials and containers used in food packaging.

Suggested books

1. W.S Frazier and D.C Weshoff, Food Microbiology, McGraw Hill, 1998
2. J. Mann and S. Trusswell , Essentials of human nutrition. 3rd edition, oxford university press, 2007
3. B. Sivashankar , Food processing and preservation, PHI,2002.

IBT5305 Green Energy

Availability of Geothermal Energy-size and Distribution, Recovery of Geothermal Energy, Various Types of Systems to use Geothermal Energy, Economics of Geothermal Energy, Concept of Wave and Tide energy: Similarities and differences, Converters, Applications, Climate and Environmental impacts, Wind Energy Basics, Wind Speeds and scales, Site selection, Operation and maintenance, Concept of wind farms and its environmental concerns, Value of wind energy, Wind energy market, Availability of Solar Energy, Nature of Solar Energy, Solar Energy & Environment, Photothermal, Photovoltaic, Present & Future Scope of Solar energy, Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for vehicles, Hydrogen Production: Direct electrolysis of water, biological and biochemical methods of hydrogen production, Potential of Nuclear Energy, Nuclear Energy Technologies: Fusion and Fission, Nuclear Waste Disposal and Nuclear disasters: Chernobyl, Hiroshima, Nagasaki, Fukushima etc.

Suggested books

1. N.K Bansal, M.K Kleeman and M. Meliss, Renewable Sources of Energy and Conversion Systems, tata McGraw Hill,1990.
2. S. Rangrajan, Wind Energy Resources Survey in India, Allied Publishers, 1990.
3. F. Kreith and J.F Kreider, Solar Energy Handbook,McGraw-Hill, 1981.

IBT5307 Medical Biotechnology and healthcare

Probes, construction of Probes, Hybridization, Diagnosis through Monoclonal Antibodies, Immunological Assay, Immuno PCR, Auto-antibodies. - Genetic analysis of diseases, Neoplastic disease diagnosis, Human genetic predisposition to diseases, Genetic analysis methodology -Direct and Indirect with specific examples of Sickle Cell Anaemia, Duchene/Backer Muscular Dystrophies, Disease prevention through Vaccines, Conventional Vaccines, Purified antigen Vaccines. Vaccine Biotechnology - Vaccine production through recombinant DNA - Various approaches for Novel

Vaccine production, Disease treatment by products of normal organisms - Microbes Plant cell/ Animal cells; Products from Recombinant Organisms /Cells/Plants/ Animals, and their advantages, AIDS, Cancer, Leukaemia, Thallasaemia, Sickle cell anaemia, Cystic Fibrosis, Muscular Dystrophy, Cancer diagnosis, Genetic analysis of Breast cancer, Oncogenes, Tumour diagnosis, Gene therapy, Gene targetting by Homologous Recombination, Embryonic Stem cell technology, Animal models for Human Diseases, Correction of Mutated Genes, Future directions.

Suggested books

1. T. Strachan and A.P Read, Human molecular genetics, 3rd Edition Wiley Bios, 2006.
2. G. Patrinos and W. Ansorage, Molecular Diagnostics, 1st Edition, Academic Press, 2005.
3. L.D Hartl and B. Jones , Analysis of genes and genomes, 3rd Edition, Jones and Bartlett Publishers, 1994.

IBT5201 Nutritional Biochemistry

Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff.Physiological energy value of foods.Measurement of energy expenditure, Review functions of carbohydrates. Digestion, absorption, utilization and storage, hormonal

regulation of blood glucose. Dietary fiber, role of fibre, Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, Review of functions of proteins in the body, Digestion and absorption. Essential and Non essential amino acids. Amino Acid Availability Antagonism, Vitamin A, D, E, K Dietary sources, RDA, Adsorption, Distribution, (ADME), Deficiency. Role of Vitamin A as an antioxidant, Role of Vitamin K. Role of Vitamin E, Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources.

Suggested books

1. L. Stryer, J.M Berg and J.L Tymoczko, Biochemistry, W.H Freeman and Co,2002.
2. A. Lehninger, Principles of Biochemistry, CBS Publishers and Distributors , 1987.
3. G.L Zubay, Biochemistry, William C. Brown Publication, 1998.

IBT5203 Algal Biotechnology

Habitat; Classification of algae; Body organization; Cell Structure; Metabolism-Nutrition & respiration; Reproduction; Life cycle, Basic culturing and analytical measurement techniques; Cultivation methods-Ponds and photobioreactors; Design of cultivation vessels; Harvest techniques; Drying techniques; Cell disruption techniques, Lipid, Protein, Carbohydrate; Organic Solvents for biomolecules extraction; High value chemicals from algae; Algal Biorefinery, Challenges and prospects; Algal biofuels production techniques-Biodiesel, Bioethanol, Biogas &Biohydrogen; Market of algal biofuels and other products- Indian & Global scenario; India Biofuels Policy, Algal strain and lipid improvement strategies-genetic engineering, chemical genetics and nutrient stress, Heavy metal removal and nutrient recovery; Commercial algal species of industrial production-Chlorella, Spirulina, Dunaliella, Hematococcus, Chlamydomonas.

Suggested book

1. A. Richmond , Handbook of Microalgal Culture: Applied Phycology and Biotechnology, Black well,2003.
2. F.E Fritsch, The structure and production of algae. Vol-I & II
3. C.M Drapcho and T.Walker , Biofuels Engineering Process Technology, McGraw Hill Publication 2008.

IBT5205 Applied Molecular Biology and Genetic Engineering

Overview of gene expression, DNA repair mechanisms, cell-cell interaction, cell signaling, proteasome degradation, DNA sequencing; Oligonucleotide synthesis; cDNA synthesis; Agarose gel electrophoresis; Pulsed field gel electrophoresis, Gene cloning strategies, Recombinant DNA technology; Cloning vectors; Expression vectors; Chimeric vectors; Fusion vectors, Trapping vectors; Shuttle vectors; Specialist vectors, Enzymes in recombinant DNA technology; Genomic and cDNA library; Applications, Methods of plant and animal transformation; Antisense RNA; RNAi; Cell nuclear replacement techniques; Embryo splitting, Gene manipulation by recombination; T-DNA and transposon tagging; Insertional and random mutagenesis; DNA shuffling; Genome editing, Polymerase Chain Reaction and variants; Hybridization techniques; Fluorescence in situ hybridization; Molecular markers

Suggested book

1. B. Alberts, Molecular Biology of the Cell, 6th ed, Garland Science, 2015.
2. J.D. Watson,Molecular Biology of the Gene, 7th ed, Pearson Education, 2013.
3. S. Rastogi and N. Pathak,Genetic Engineering, Oxford University Press, 2009.

IBT502 Functional Genomics and Proteomics

Nucleic acid and protein databases; Genome sequencing; Automated DNA sequencers; Genome Projects, Genome annotation; Phylogenetic analysis; DNA microarray; Serial analysis of genome expression; Gene knockouts, Proteome sequencing, Automated amino acid analyser; 2D gel electrophoresis; Mass spectrometry; Protein chip, DNA binding motifs; Methods for detecting DNA-protein interactions; ChIP, Gel retardation assay, Modification protection assay, Modification interference assay, Microplate capture and detection assay, Reporter assays, DNA pull-down assay, Protein motifs and domains; Methods for detecting protein-protein interactions; Significance of GFP tag, TAP tag, Y2H, Y3H, Phage display, Intein splicing, Co-IP, Single nucleotide polymorphisms; Adverse drug reactions; Drug responses; Drug discovery and drug development; Personalized medicine; Drug-DNA interactions

Suggested book

1. A. Lesk, Introduction to Genomics, 2nd ed, Oxford University Press, 2012.
2. A.M. Campbell and L.J. Heyer, Discovering Genomics, Proteomics and Bioinformatics 2nd ed, Benjamin Cummings, 2006.
3. R.M. Twyman, Principles of Proteomics ,2nd ed, Garland Science, 2013.

SEMESTER II

IBT504 Bioprocess Engineering and Reactor design

Criteria for good medium, medium requirements for fermentation processes, medium optimization methods, batch and continuous heat sterilization of liquid media, air sterilization, Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, Kinetic models for microbial growth, Monod model, growth of filamentous organisms, product formation kinetics, substrate and product inhibition on cell growth and product formation, Design and operation of various bioreactors, viz CSTF, fed batch systems, air-lift bioreactors, fluidized bed, plug Flow and Packed Bed Bioreactor, Biochemical process variables and their measurements; Microbial biosensors, Use of computer in control and optimization of microbiological processes, Removal of microbial cells and solid matter, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction, chromatography, membrane process, drying and crystallization. Lab-To determine the concentration of protein content by Lowry method, To determine the concentration of sugar by 3, 5 dinitrosalicylic acid method, To determine the optimum pH for given enzyme sample, To determine the optimum temperature for given enzyme sample, To study the immobilization of invertase enzyme, Measurement of citric acid production by Aspergillusniger with TLC, Determination of thermal death point (TDP) of the given microorganism, Production of ethanol from yeast fermentation of sugars

Suggested book

1. J.E Baily and D.F Ollis, Biochemical Engineering Fundamentals, McGraw Hill,1986.
2. W.R Veith, Bioprocess Engineering- Kinetics, Mass transport, reactors and gene expression, John Wiley and Sons Inc,1994.
3. M.L Shuler and F. Kargi, Bioprocess Engineering Basic Concepts, Prentice Hall ,1987.

IBT5402 Advanced Environmental Biotechnology

Interaction between environment and biota, Limiting factors, Energy flow, food chain, Environmental impact assessment, Principles of conservation, Conservation strategies, sustainable development, Global environmental problems: UV-B radiation, ozone depletion, green house effect and acid rain, Types of pollution and pollution analysis: noise and air pollution. Noise pollution: Types, sources, measurement, impact on ecosystem and control. Air pollution: Types, sources, method of sampling, Impurities in water, water pollution by industrial waste, examination of water, collection of water samples, water analysis: physical, chemical and biological. Standards of water quality, Water treatment processes, In-situ and ex-situ bioremediation, bioremediation of oil spills and heavy metal pollution, use of microbes in bioremediation, hydroponic system, pollution control boards and pollution control acts, Sewage sludge treatment and utilization, composting and vermiculture, bioremediation of contaminated soils and waste lands, radioactive products waste disposal, Sources of effluents, impact on ecosystem and treatment of industrial effluents. Lab- Environmental Impact Assessment, Measurement of Air and Noise Pollution, Measurement and control of pH, Measurement of Conductivity and TDS in water, Measurement of Dissolved Oxygen in given water sample, Measurement of Carbon dioxide and Hardness of water, Analysis of Ammonia and Ammonium in water, Analysis of Nitrite, Nitrate and Total Nitrogen in water, Measurement of Biochemical Oxygen Demand and Chemical Oxygen Demand, Analysis of industrial effluent, Biogas production/Vermicomposting.

Suggested books

1. B.E Rittmann and P.L Mccarty, Environmental Biotechnology: Principle and Applications, McGraw Hill publishing company Ltd, 2001.
2. D.W Connell, Basic concepts of Environmental chemistry, Lewis publishers, 2005.
3. R.T Wright and B.J Nebel., Environmental Science towards a Sustainable Future, Prentice Hall of India, 2004.

IBT5406 Quality Management

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs –Analysis, Techniques for Quality Costs, Evolution of Quality Control, Basic concepts of Total Quality Management, Historical Review, Leadership – Concepts, Organization structure and design, quality function, decentralization, designing and fitting, organization for different type products and company, economics of quality value and contribution, quality cost, Theory of control charts, measurement range, construction and analysis of R charts, process capability study, use of control charts, Defect study, identification and analysis of defects, correcting measure, factors affecting reliability, MTTF, calculation of reliability, building reliability in the product, The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System –Elements, Implementation of Quality System, Documentation, Quality Auditing, QS9000, ISO 14000.

Suggested book

1. Lt. Gen. H. Lal, Total Quality Management, Eastern Limited, 1990.
2. D.H Besterfiled , Total Quality Management, Pearson Education Asia,1999.
3. M. Zairi, Total Quality Management for Engineers ,Wood Head Publishers, 1991.

IBT5404 Biopolymer Technology

Biopolymers – The current scenario, different biopolymers – produced from variousrenewable resources, characteristics, merits and demerits over conventional polymers, Biopolymers and Artificial Biopolymers in Biomedical Applications, an Overview, Novel Synthesis of Biopolymers and Their Medical Applications, Synthesis and modification of different Biopolymers like xanthum gum, Source, characteristics and properties of Biosurfactants; Production of Biosurfactants via the fermentation and biotransformation routes; Production of Biosurfactants with immobilized cells; Integrated bioprocess for continuous production of Biosurfactants, Different types of bioplastics; Starch-based plastic, Cellulose-based plastic. Aliphatic polyesters; Poly-3-hydroxybutyrate (PHB), Polylactic acid (PLA). Polyamide. Bio-derived polyethylene Advantages of bioplastic over petroleum-basedpolymer Mechanism of synthesis of Poly (b- hydroxybutyric acid) (PHB), An Overview of Available Testing Methods, Comparison of Test Systems for the examination of the Fermentability of Biodegradable Materials, Structure-Biodegradability Relationship of biopolymers.

Suggested book:

1. E. Chiellini and H. Gil, Biorelated Polymers: Sustainable Polymer Science and Technology, Springer 2001.
2. R.M Johnson, L.Y Mwaikambo and N. Tucker, Biopolymers, RapraTechnology, 2003.
3. N. Kosaric ,Biosurfactants, Marcell Dekker Inc, 1993.

IBT5408 Plant Molecular Farming

Definition and common perception of molecular farming; Transgenic plants as bioreactors-an attractive alternative to current forms of manufacture of various compounds, Major targets for carbohydrate and lipid molecular farming; Introduction to the crucial metabolic pathways and the involved gene functions in plants & other suitable organisms, Medium-chain, saturated & mono-unsaturated fatty acids, improvement of plant oils, Production of rare fatty acids, polyunsaturated fatty acid having pharmaceutical and nutraceutical values, Various gene functions involved in the production of polyhydroxy butyrate & polyhydroxy alkanoate co-polymers; Strategies for production of biodegradable plastics in plants, Enzymes for industrial and agricultural uses, medically related proteins-antibodies, subunit vaccines, protein antibiotics, The oleosin system: insulin production, production of biopharmaceuticals in plants; Chloroplast: a clean high-level expression system for molecular farming.

Suggested books:

1. A. Slater , N.W Scott and M.R Fowler, Plant Biotechnology, Oxford University Press, 2008.
2. S..B Primrose and R.M Twyman , Principles of Gene Manipulation and Genomics, Blackwell Publishing, 2006.
3. U. Satyanarayana, Biotechnology, Books and Allied (P) Ltd,2005.

IBT5302 Biopharmaceuticals

Pharmaceutical Industry & Development of Drugs; Types of Therapeutic Agents and Their Uses; Economics and Regulatory Aspects, Mechanism Of Drug Action; Physico-Chemical Principles Of Drug Metabolism; Radioactivity; Pharmacokinetics, Types of Reaction Process And Special Requirements For Bulk Drug Manufacture, Compressed Tablets; Dry And Wet Granulation; Slugging Or Direct Compression; Tablet Presses; Coating of Tablets; Capsule Preparation; Oval Liquids – Vegetable Drugs – Topical Applications; Preservation Of Drugs; Analytical Methods, Various Categories of Therapeutics like Vitamins, Laxatives, Analgesics, Contraceptives, Antibiotics, Hormones and Biologicals, Strategy and Phasing for Drug Safety, Acute Toxicity Testing in Drug Safety Evaluation, Special Concerns for the Preclinical Evaluation of Biotechnology Products.

Suggested books:

1. H. Klefenz , Industrial pharmaceutical biotechnology, John Wiley sons, 2002.
2. Susanna(Ed),Wu-Pong, and J. Robinson, Biopharmaceutical drug and design and development, Humana Press, 2007.
3. H. A Kirst, W. Yeh and J. Milton , Enzyme Technologies for pharmaceutical and biotechnological applications, wiley-vch Verlag, 2003.

VLS5302Minor Project

IBT5304 Biochemical Thermodynamics

System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry. Second law – Entropy and universe, Third law of thermodynamics, Reversible work, exact differentials and function of state, first and second law, The electrochemical potential, External forces and steady state, Fick's Law, Energetics of metabolic pathways – energy coupling, stoichiometry –energetic analysis of cell growth and product formation– elemental balances. Thermodynamics of Biological Systems, Visualization of the potential, Steady

velocity and steady flow Fick's law and diffusion. Local Equilibria and Steady State: Energy vs. Power, Gibbs free energy and equilibrium, Chemical potential, ionic solutions, Equilibrium constant, standard state in biochemistry, Acid and bases, chemical coupling, Rate of a reaction, rate constant and order of the reaction, effect of temperature, collision and transition state theory, Electron transfer kinetics, Enzyme kinetics and inhibition.

Suggested book:

1. J.M Smith , H.C Van Ness , M.M Abbot , Chemical Engineering Thermodynamics, 6th Edition, McGraw-Hill, 2001.
2. D.T Haynie, Biological Thermodynamics, Cambridge press, 2008.

IBT5306: Transport Phenomenon

Molecular and turbulent diffusion, Diffusion coefficient, Flick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition, Diffusion in solids, Solid-gas equilibria, Different modes of drying operation, Types of batch and continuous dryer Definitions of moisture contents, Rate of batch drying, Time of drying, Gas-Liquid equilibria. Henry's Law, Selection of solvents, Absorption in tray column, Graphical and analytical methods, Absorption in packed column, Design equation for packed column, Review of basic concepts – Conservation of Mass, Conservation of Energy, Momentum Balance – Momentum Balance in a Circular Pipe, Flow Velocity Profile, Introduction, Conduction: Basic concepts of conduction in solids, liquids and gases, One and two dimensional heat conduction. Principles of convection, Basic laws of heat transfer by radiation, black body and gray body concepts, solar radiations, combined heat transfer coefficients by convection and radiation. Introduction of Heat Transfer Equipments.

Suggested Books:

1. J.P Holman, Heat Transfer, 9 th ed, McGraw Hill, 1989.
2. A..S Foust, Principles of Unit Operations,John Wiley ,1980.
3. R. B. Bird , Transport Phenomena, 2nd Edition, Wiley,2006.

IBT5202: Nanobiotechnology

Nano-definition, The fundamental Science behind nanotechnology- Synthesis and Characterizations of Nanoscale Materials. Strategies for Nano architecture, Fabrication Technologies, Fullerenes - Properties and Characteristics.Carbon Nanotubes - Characteristics and Applications Quantum Dots and Wires. Gold Nanoparticles.Nanopores, Functional principles of Bionanotechnology: Information driven nanoassembly, Energetics, Role of enzymes in chemical transformation, Structure and functional properties of Biomaterials, Overview of natural Bionanomachines: ThymidylateSythetase, ATP synthetase, Actin and myosin, Opsin, Antibodies and Collagen, Nano-biotechnology in drug Delivery.Nanoscale Devices for Drug Discovery.Micelles for Drug Delivery. Protein targeting: Small Molecule-Protein Interactions. Nanotechnology for Cancer Diagnostics and Treatment, Principles of toxicology; toxicology models, experimentaltoxicology studies; activation and detoxification mechanisms. Pharmokinatics and pharmacodynamics, Applications, Risks and Precautions.

Suggested books:

1. T.Pradeep ,NANO, Tata McGraw ,2006.
2. C.M Niemeyer, C.A Mirkin, (eds.), Nanobiotechnology: Concepts, Applications and Perspectives, Wiley-VCH Weinheim, 2004.
3. D.S Goodsell, Bionanotechnology, John Wiley & Sons, 2004.

IBT5204 **Biosensor Technology**

A historical perspective; Definition and Expanding Needs of Biosensors; Advantages and limitations; Biosensor Economics; various components of biosensors, Biocatalysts based biosensors, bio affinity based biosensors & microorganisms based biosensors, biologically active material and analyte. Types of membranes used in biosensor constructions, Various types of transducers; principles and applications; electrochemical biosensors, Bio- and chemi-luminescence for fiber-optic biosensors; piezoelectric biosensors, Silicon, glass and metal electrodes; bio-compatibility of materials; Existing types of Biosensors: Miniaturisation and micro-systems including sensing using optical techniques, The purpose and practice of modeling; flux diagram for the membrane/enzyme/ electrode, Potentiometric enzyme electrodes, Optical and photometric biosensors, Immunosensors, Biosensors in medicine and health care (for glucose monitoring, DNA analysis, etc.); biosensors for agriculture and food; Low cost biosensor for industrial processes for online monitoring.

Suggested books:

1. B.D Malhotra and C.M Pandey, Biosensors: Fundamentals and Applications, Smithers Rapra Tech, 2017.
2. A.P.F Turner, I. Karube and G.S Wilson, Biosensors Fundamentals and applications, Oxford Univ. Press, 1990.
3. M. Ashok and K. Rogers, Enzyme & Microbial Biosensors: Techniques and Protocols (Methods in Biotechnology) (1e), Humana Press, 1998.

IBT5206 **Advanced computational Genomics**

Types, Overview of Biological Databases and Retrieve Nucleic acid databases: NCBI: Pubmed, Entrez, Blast, OMIM, Books, Taxonomy, Structure, Locuslink. Protein Databases- Primary, Functional, Composite, Secondary, Structural classification database. Structure of DNA, Polymorphisms in DNA Sequence, Human Genome Project, Complete Genome Sequences, Functional Annotation, Local alignment, Global alignment, Scoring matrices- PAM, BLOSUM, Gaps, Dot Plots. Dynamic programming Approach: Needleman and Wunsch Algorithm, Smith and waterman Algorithm, Heuristic Approach: BLAST, FASTA, Global and local alignments, scoring matrices and gap penalties, filtering, position specific scoring matrices, internet resources, uses of multiple, Gene Ontology, GO Annotations, Manual Annotations, Computational Annotation Methods, Functional Analysis of Datasets, Novel Data Annotation and Curation; Pharmacogenomics Applications; Database Creation; Development of a Predictive Tool

Suggested books:

1. F.Dardel and N.Hardy, Bioinformatics: Genomics and Post-Genomics, John Wiley & Sons India.
2. N.J Chikhale and V.S Gomase , Bioinformatics: Theory and Practice, Himalaya Publication House.
3. A.M Campbell and L.J Heyer, Discovering Genomics, Proteomics and Bioinformatics, , Pearson Education,2003.

IBT5208: Food Microbiology

History of Microorganisms in Food-developments: Common Food borne Bacteria, Molds Role, and Significance of Microorganisms in Foods. Parameters Affecting Microbial Growth: Intrinsic, Extrinsic, Fresh meat, Processed meat and poultry, Culture, Microscopic, and Sampling Method for detecting

microbes, Physical, Chemical methods, Whole animal assays, Immunological methods, Fruit and products like jam, jelly, sauce, juice; Microbiology of cereal and cereal products like bread, biscuits, Confectionary, Staphylococcal, E. coli, Salmonellosis, shigellosis, Listerial infections. Mycotoxins, Aflatoxins, Alternaria Toxins, Toxigenic Phytoplanktons and viruses, Water removal, chilling and refrigeration, freezing, modified atmosphere, cleaning and sanitization, Beneficial Uses of Mic roorganisms in Food Intestinal Beneficial Bacteria-Concept of Prebiotics and Probiotics, Genetically modified foods. Biosensors in food

Suggested books:

1. M.R Adams and M.O Moss, Food Microbiology, Royal Society of Chemistry,2015.
2. M.James and Jay, Modern Microbiology, Springer, 2005.
3. B. Ray, Fundamental Food Microbiology, CRC press, 1996.

SEMESTER III

IBT6401 Enzyme Technology and Industrial Application

Introduction, nomenclature and classification of enzyme. Mechanism and catalysis, Enzymatic catalysis in biphasic system, Ribozyme, Abzyme (catalytic antibodies), isoenzymes, coenzymes and cofactors, Kinetics of substrate and multisubstrate reactions; King-Altman's method, Analysis of kinetic data, Inhibition - substrate, product and inhibitors, Allosteric regulation of enzymes, Methods of immobilization, External and internal diffusional mass transfer limitation, Effectiveness factor and modulus; electrostatic and stearic effects in immobilized enzyme systems, Reactors for Batch/ continuous enzymatic processing, choice of reactor type: idealized enzyme reactor systems; Mass transfer in enzyme reactors: Steady state analysis of mass transfer and biochemical reaction in enzyme reactors, Production and purification of crude enzyme extracts from plant, animal and microbial sources; methods of characterization of enzymes, Application of enzymes in different industries (Pulp and Paper industry, Detergent industry, Textile industry, Food processing industry), Medical and analytical application of enzyme, Biosensor. Lab- Effect of temperature on enzyme activity, Studies on Enzyme kinetics, Effect of pH on enzyme activity, Kinetics of Enzyme inhibition, Enzyme immobilization techniques, Characterization of Immobilized enzymes and their applications, Estimation of the amount of protein content in the given sample by Lowry method.

Suggested books:

1. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis by R.A. Copeland. Publisher: John Wiley and Sons Inc.
2. Enzymes by Palmer (2001): Horwood Publishing Series.
3. Fundamentals of Enzymology by Price and Stevens (2002). Publisher: Oxford University Press.

IBT6403 Metabolic Engineering

An overview of cellular metabolism-transport processes- Fueling reactions -glycolysis-fermentative pathways-TCA cycle and oxidative phosphorylation-anapleroticpathways -catabolism of fats, organic acids and amino acids -biosynthetic reactions of amino acids – nucleic acids, fatty acids and other building blocks, Stoichiometry of cellular reactions -reaction rates-dynamic mass balances-Yieldcoefficients and linear rate equation; Material Balance and data consistency –blackbox model elemental balance -heat balance, Overview of enzyme kinetics – simple reversible inhibition systems – irreversibleinhibition – allosteric enzymes; cooperativity – regulation of enzyme concentration,

Theory – overdetermined systems – underdetermined systems – sensitivity analysis –methods for the experimental determination of metabolic fluxes by isotope labelling direct flux determination from fractional enrichment, Fundamentals of Metabolic control analysis -determination of flux controlcoefficients – MCA of Linear pathways – branched pathways – theory of largedeviation, Applications of metabolic engineering

Suggested books:

1. G.N Stepanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering-Principles and methodologies, Academic Press, 1998.
2. D.I.C Wang , C.L Cooney ,A.L Demain , P. Dunnil and A.E Humphery, Fermentation And Enzyme Technology, John Wiley And Sons. 1980

IBT6405 Vaccine Technology

Overview of antigen-antibody interaction and immune response, Active and passive immunization; Booster dose, Live and attenuated vaccines; Inactivated vaccines; Toxoids; Subunit vaccines; Conjugated vaccines; Recombinant vaccines; DNA vaccines; Edible vaccines; Adjuvanted vaccines; Non-adjuvanted vaccines; Synthetic vaccines; Polyvalent vaccines; Monoclonal vaccines, Vaccines against bacterial diseases; Egg based vaccines; Cell based vaccines; Investigational vaccines; Antigen purification technologies, Steps involved in vaccine manufacturing; Vaccine formulation; Roles of adjuvants, stabilizers, preservatives, antibiotics in vaccine formulation, Clinical trials; Regulatory authority

Suggested reading:

1. I.M Roitt, P.J Delves, S.J Martin and D.R Burton, Roitt's Essential Immunology, John Wiley & Sons, Inc., 13th Edition, 2017.
2. R.W Sears ,The Vaccine Book: Making the Right Decision for Your Child, Little Brown and Company, 1stedition, 2007
3. K.A Feemster, Vaccines: What Everyone Needs to Know, Oxford University Press, 1stedition, 2017

IBT6407 Advanced Biochemistry

Amino acids- Classification, structure and function, proteins- primary, secondary, tertiary and quaternary structure, Ramachandran plot, super secondary structures and helix loop. Classification of enzymes. How do enzymes work: activation energy, substrate specificity. Enzyme-substrate interaction, Effect of temperature and pH on enzyme action. Enzyme Kinetics, Introduction to metabolism: Anabolism, catabolism, metabolic pathways. Characteristics of metabolic pathways, glycolytic pathway. alcohol and lactic acid fermentation. TCA Cycle, Lipid metabolism: Hormonal regulation of the mobilization of triglycerides from adiposities. Transport of fatty acid into mitochondria. Beta oxidation of saturated fatty acid, Electron Transport Chain, Starve-Fed cycle. Glucose homeostasis. Switching of metabolism of liver between starve and fed cycle. Metabolic relationship of tissues in various nutritional and hormonal states, Feed back inhibition by allosteric modulation of enzymes. Covalent modifications of enzymes. Isozymes. Propetolytic cleavage. gene expression in prokaryotes and eukaryotes.

Suggested books:

1. D.L Nelson , M.M Cox, Lehninger's Principle of Biochemistry, 5th Ed, W. H. Freeman, 2008.
2. L. Stryer, Biochemistry 7th ed, W. H. Freeman & Company, 2002.
3. T.M Devlin, Textbook of Biochemistry with Clinical Correlations 4th Ed, Wiley-Liss publication. 1997

IBT6301 Industrial waste water treatment

Waste disposal management, Methods of waste disposal, effect of industrial wastes on streams and sewerage systems, physico-chemical and biological treatments of waste and their evaluation in respect of treatment, Characteristic features of wastes (solid, liquid and gaseous emission), toxic byproducts generated from paper and pulp industries, thermal power station, distillery, textile industry, Small and large scale industries for waste reduction and remediation, various methods for waste alteration, recycling plants, material restoration and conservation. Economic sustainability and government support for joint treatment of raw effluent, municipal sewage and debris, Microbiology of Waste water treatment. Different microbes responsible for Wastewater treatment, Advanced technologies of Wastewater treatment: Softening, Ion exchange, Reverse Osmosis Technologies, Ultrafilteration, Selective memebrane.

Suggested books:

1. S. P. Mahajan, Pollution Control in Process Industries, Tata McGraw Hill Publications.
2. W. W Eckenfelder Jr., Industrial Water Pollution Control, McGraw Hill Publications.
3 N.K Ostler, Industrial Waste Stream Generation, Prentice Hall

IBT6303: Metagenomics

Metagenomics, meta-transcriptomics, functional metagenomics, identification and analysis of microbial community, Identification of infectious microbes causing diseases (gut microbiome), Identification of beneficial microbes, nutrient recycling and plant microbe interaction, Microbial community in environment, identification of microbes for sustainable ecology and environmental remediation, Identification of novel enzymes and microbes for industrial applications, Identification of microbes producing novel drug /antibiotics producing microbes/genes.

Suggested books:

1. K.E Nelson , Encyclopedia of Metagenomics, Springer-Verlag New York, 2015.
2. T.C Charles , M.R Liles and A. Sessitsch, Functional Metagenomics: Tools and Applications. Springer International Publishing,2017.
3. K.E Nelson, Metagenomics of the Human Body, Springer-Verlag New York, 2011

IBT6305 Transgenic Technology

Agrobacterium tumefaciens mediated transformation; Plant and animal virus mediated transformation Microprojectile bombardment; Electroporation; Microinjection; Silicon carbide whiskers; Ultrasonication; Laser beam irradiation; Lipofection; Chemical methods; Chloroplast transformation; In planta transformation, Recombinases; Zinc finger nucleases; CRISPR/Cas 9;Transcription activator-like effector nuclease;Trap vectors, Antisense RNA; RNA interference; dsRNA mediated DNA methylation; dsRNA mediated RNA degradation; Co-suppression; Insertional mutagenesis;

T-DNA tagging; Transposon tagging; Knockouts, Selectable markers; Reporter assays; Phenotypic analysis; Analysis of knockouts, Applications in agriculture, animal husbandry, medical, food, environmental fields;Bt cotton case study;Gene therapy; Purification;Surface display; Function characterization

Suggested books

1. S.B Primrose & R.M Twyman, Principles of Gene Manipulation & Genomics Seventh edition, 2006
2. J. Sambrook and D.W Russel, Molecular Cloning: A Laboratory Manual Third edition, Cold Spring Harbor Laboratory Press, 2001
3. S. Rastogi and N. Pathak ,Genetic Engineering, Oxford University Press, 2009

IBT6307 Biomaterials

Definition, requirements of biomaterials, Comparison of properties of some common biomaterials, effects of physiological fluid, biological responses, physical and surface properties, Stainless steel- Co-based alloys- Ti and Ti-based alloys, corrosion behaviour, Hard tissue and soft tissue replacement implant, Types of bioceramics, Importance of wear resistance, Composite implant materials- Mechanics of improvement of properties by incorporating different elements, Classification, Viscoelastic behaviour, Biodegradable polymers for medical purposes, Synthetic polymeric membranes and their biological applications, Biocompatibility, blood compatibility Toxicity tests, In-vitro and In-vivo testing. Methods of mechanical testing of biomaterial, tensile, compression. wears, fatigue, degradation tests.

Suggested books:

1. J.D Bronzino, The Biomedical Engineering Hand Book ,Second Edition, CRC Press, 2000.
2. J.Y Wong and J.D. Bronzino, Biomaterials, CRC Press, 2007.
3. B.D Ratner, Biomaterials Science-An Introduction to Materials in Medicine. Third Edition, Elsevier press. 2013

IBT6201 Bioethics, Biosafety and IPR

Personal ethics: profession and professionalism, Biotechnology and ethics: Biotechnology in agriculture and environment: benefits and risks, Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IPR, Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure, Forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; International patenting, Patent infringement, Good Lab Practices, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels GMOs and LMOs and their environmental impact, The legal and socioeconomic impacts of biotechnology, public education of the processes of biotechnology involved in generating new forms of life for informed decision making

Suggested books:

1. M.W Martin and R.Schinzinger, Ethics in engineering, III Edition, Tata McGraw- Hill, 2003.
2. A. Sasson, Biotechnologies and Development, UNESCO Publications, 1988.
3. K.K Singh, Intellectual property rights on Biotechnology, Springer.

IBT6203 Bioprocess Plant Design

Introduction to Design – nature of design – Technical feasibility survey, Mass andenergy balance, process development – data acquisition – design data information ofproject - Organization of project – Project documentation – codes and standards, Equipment selection and specifications-materials of construction – flow sheeting -piping and instrumentation – process safety and loss prevention, Introduction – plant location and site selection – site layout- plant layout utilities –environmental considerations– waste management – visual impact – government regulations and other legal restrictions, Selection and specification of equipment for handling fluids and solids; Selection, specification, design of heat and mass transfer equipment used in bioprocess industries; Design of facilities for cleaning of process equipment used in biochemical industries, Design of fermentation, Design considerations for maintaining sterility of processing equipment, Production plants; Bioprocess validation; Safety considerations

Suggested books:

1. E.E.Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Butterworth-Heinemann.
2. R.K Sinnott, J.M Coulson and J.F Richardsons, Chemical Engineering, Butterworth Heinemann III edition– 2002.
3. M.S Peters and K.D Timmerhaus, Plant Design and Economics for Chemical Engineers, Mcgraw Hill 4thEdition, 1989.

IBT6205: Advanced Animal Biotechnology

Animal cell culture, Basic principles, serum free and serum based media, Scaling-up, characterization and preservation of cell lines, Cytotoxicity and viability assays, Classification of scaffold materials, criteria for ideal scaffold, control of architecture, Scaffold design and fabrication, Tissue Engineering of Skin, Bone, Cartilage, Neurons, Cell sources, Stem cells, Embryonic Stem Cells, Adult Stem Cells, Hematopoetic Stem Cells, Cell Differentiation/ Signaling, Generation of modified stem cells, Animal diseases, diagnosis, therapy, variations of diseases, modes of transmission of diseases, control and management of disease spreading, Biotechnological application in animal improvement, Embro biotechniques, in-vivo and in-vitro embryo production and preservation, transgenic animals and biopharming, Molecular Diagnostics &PCR, DNA probes, Monoclonal antibody and hybridoma technology, application of mAbin diagnostics and therapeutics.

Suggested books

1. R.I Freshney, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Sixth Edition, John Wiley & Sons,2010.
2. C.A Pinkart, Transgenic Animal Technology, Academic Press, 1998.
3. S.K Gahlawat, J.S Duhan and P. Kaur Advances in Animal Biotechnology and its Applications, , Springer Nature Singapore Pte Ltd. 2018

IBT6207 Microbial Biotechnology

Preservation and Maintenance of Industrial Microorganisms. Media for industrial fermentation. Air and Media Sterilization. Microbial synthesis of organic acids (Citric acid), alcohol (ethanol), alcoholic beverages (wine), antibiotics production (penicillin), vitamin(B12) and amino acid (glutamic acid), SCP production- mushroom cultivation; Bio fertilizers and bio insecticides. Methods of isolation of

pathogenic organisms; vaccine production; Insulin production, Microbes in waste water treatment, microbial ore leaching and mineral recovery, oil recovery. Development of methane and hydrogen fuel

Suggested books:

1. P.F Stanbury and A. Whitaker,Principles of Fermentation Technology,Pergamon Press, Oxford,1984.
2. A.L Demain and J.E Davies, Manual of Industrial Microbiology and Biotechnology, III edition , ASM press, 1999.
3. L.E Casida Jr, Industrial Microbiology, New Age International, 2007.

IBT651 Research Project

IBT601 Major Project I

SEMESTER IV

IBT652 Research Project

IBT602 Major Project II

DEPARTMENT OF CIVIL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Geotechnical Engineering)

Programme Specific Outcomes

Post graduate student will

1. Have fundamental and allied knowledge required for subsurface problems which arise due to infrastructure development.
2. Gain competency in the design of shallow/deep foundations, earth retaining structures embankment and earthen dams, underground structures.
3. Understand problems related o stability of slopes and its preventive measures.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN GEOTECHNICAL ENGINEERING (GTE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	GTE501	Advanced Soil mechanics	Core	4	3	0	2	15	25	20	40	-	17
	2	GTE503	Advance Foundation Engineering	Core	4	3	0	2	15	25	20	40	-	
Group B	3	GTE5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	GTE5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	GTE5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	GTE502	Rock Mechanics	Core	4	3	0	2	15	25	20	40	-	17
	2	GTE504	Soil dynamics and machine foundation	Core	4	3	0	2	15	25	20	40	-	
Group D	3	GTE5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	GTE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	GTE5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	GTE651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	GTE601	Major Project I	Core	3						40	60		
	2	GTE6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	15	
	3	GTE6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	GTE6201/6203/.....	Elective 9	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group F	1	GTE652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	GTE602	Major Project II	Core	12	0	0	12	0	-	0	100	0	

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	GTE5401	Geo-environmental Engineering	Elective	4	3	0	2	15	25	20	40	-
	2	GTE5403	Geotechnical Exploration		4	3	0	2	15	25	20	40	-
	3	GTE5405	Application of remote sensing and GIS in Geotechnical Engineering		4	3	0	2	15	25	20	40	-
	4	GTE5407	Cost Management of Engineering Project		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	GTE5301	Geotechnical Earthquake Engineering	Elective	3	3	0	0	20	0	30	50	-
	2	GTE5303	Stability Analysis of Slopes		3	3	0	0	20	0	30	50	-
	3	GTE5305	Earth Pressure & Earth Retaining Structures		3	3	0	0	20	0	30	50	-
	4	GTE5307	Pavement analysis and Design		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	GTE5201	Seminar	Elective	2	0	0	2	-	100	-	-	-
	2	GTE5203	FEM in Geotechnical Engineering		2	2	0	0	20	0	30	50	-
	3	GTE5205	Offshore Geotechnical Engineering		2	2	0	0	20	0	30	50	-
	4	GTE5207	Composite Material		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	GTE5402	Theoretical Soil Mechanics	Elective	4	3	0	2	15	25	20	40	-
	2	GTE5404	Unsaturated Soil Mechanics		4	3	0	2	15	25	20	40	-
	3	GTE5406	Critical State Soil Mechanics		4	3	0	2	15	25	20	40	-
	4	GTE5408	Operational Research		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	GTE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	GTE5304	Soil Structure Interaction		3	3	0	0	20	0	30	50	-
	3	GTE5306	Disaster Mitigation and Management		3	3	0	0	20	0	30	50	-
	4	GTE5308	Uncertainties, risk and reliability in Geotechnical Engineering		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	GTE5202	Ground Water Hydrology	Elective	2	2	0	0	20	0	30	50	-
	2	GTE5204	Physical Modelling in Geomechanics		2	2	0	0	20	0	30	50	-
	3	GTE5206	Numerical and Analytical Method in Geomechanics		2	2	0	0	20	0	30	50	-
	4	GTE5208	Waste to Energy		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	GTE6401	Plasticity & Fracture Mechanics in Rock Structures	Elective	4	3	0	2	15	25	20	40	-
	2	GTE6403	Theory of Elasticity and Plasticity in Geomechanics		4	3	0	2	15	25	20	40	-
	3	GTE6405	Design of Underground/Sub Structures		4	3	0	2	15	25	20	40	-
	4	GTE6407	Structural Geology		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	GTE6301	Geosynthetics	Elective	3	3	0	0	20	0	30	50	-
	2	GTE6303	Ground Improvement Techniques		3	3	0	0	20	0	30	50	-
	3	GTE6305	Excavation Technology		3	3	0	0	20	0	30	50	-
	4	GTE6307	Probability and Statistical Methods in Engineering		3	3	0	0	20	0	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	2	GTE6201	Design of Underground Excavations		2	2	0	0	20	0	30	50	0
	3	GTE6203	Foundations on Weak Rocks		2	2	0	0	20	0	30	50	0
	4	GTE6205	Geotechnical Design Studio		2	0	0	4	-	40	-	-	60

SEMESTER I

Courses

GTE 501 Advanced Soil mechanics

Clay mineralogy, clay-water electrolyte system, soil structure and fabric, Special soils: collapsible & sensitive clays, loessic, bouldary, and expansive soils Effective stress, pore pressure, hydraulic conductivity and its directional variation, electro osmosis Seepage behavior of soil-flow net constructions by various technique, seepage in layered soils, filter design, seepage through dam body Consolidation: one-dimensional and generalized consolidation theories, primary and secondary consolidation, determination of Cv by various methods, visco- elastic models, sand drains, effect of smear, numerical solutions, consolidation settlements. Shear behavior of soils, pore pressure parameters, UU, CU & CD tests, stress path method for settlement analysis. Total & effective stress-path, water content contours, stress history, anisotropy of strength, thixotropy, creep, determination of in situ undrained shear strength, stress-strain characteristics of soils, determination of modulus values

Suggested Books:

1. Soil Mechanics: Principle and Practice: GE Barnes, (2000) (ISBN 9-03-088753-7)
2. Advance Soil Mechanics: BM Das (1997), (ISBN 0-77-04915-8)
3. Soil Mechanics: TW Lambe and RV Whitman (1987), (ISBN 0-71-6059714-1)
4. Fundamentals of Soil Behaviour: James K. Mitchell (1993), (ISBN 7-83-4697512-6)
5. Principles of Soil Mechanics: RF Scott (1963), (ISBN 9-54-3564799-8)

GTE 503 Advance Foundation Engineering

Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests, Shallow foundations, requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes. Pile foundations, methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, negative skin friction of piles, laterally loaded piles, pile load tests, analytical estimation of load- settlement behavior of piles, proportioning of pile foundations, lateral and uplift capacity of piles. Well foundation, IS and IRC codal provisions, elastic theory and ultimate resistance methods, Coffer dams, various types, analysis and design Foundations under uplifting loads. Foundations on problematic soils: Foundations for collapsible and expansive soil

Suggested Books:

1. Bowles. J.E., (1997),"Foundation Analysis and Design, Tata McGraw-Hill International Edition"
2. Das B.M., (1999), "Shallow Foundations: Bearing capacity and settlement, CRC Press,"
3. Tomlinson M.J.,(1994)," Pile design and construction Practice, Chapman and Hall Publication,".
4. Poulos, H. G. and Davis, F. H., (1980) "Pile Foundation Analysis and Design", Wiley and Son

GTE5401 Geo-environmental Engineering

Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium. Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization. Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction. Concepts of waste containment; Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, desirable properties of soil; contaminant transport and retention; contaminated site remediation. Soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis. contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

Suggested Books:

1. Mitchell, J.K and Soga, K., (2005) "Fundamentals of Soil Behavior, John Wiley and Sons Inc.,".
2. Fang, H-Y.,(1997) " Introduction to Environmental Geotechnology, CRC Press"
3. Daniel, D.E, (1993) "Geotechnical Practice for Waste Disposal, Chapman and Hall,".
4. Rowe, R.K., Quigley, R.M. and Booker, J.R.,(1995) " Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon,"
5. Reddi, L.N. and Inyang, H.F, (2000) "Geo-environmental Engineering - Principles and Applications, Marcel Dekker Inc"
6. Sharma, H.D. and Lewis, S.P,(1994) "Waste Containment Systems,"

GTE5403 Geotechnical Exploration

Surface and sub-surface exploration methods. Aerial and remote sensing techniques, Geophysical methods, electrical resistivity, seismic refraction, applications. Rock drilling, Core samplers, Core boxes, Core orientations. Sampling techniques, Sampling disturbances, storage, labelling and transportation of samples, sampler design Logging, stratigraphic profile, scan line survey. Laboratory tests, report. Stresses in rocks. Stress anisotropy and stress ratio. Stress relief and compensation techniques, USBM, door stopper cells, flat jack, hydro fracture, strain rosette and dilatometers. Deformability, pressure tunnel and bore hole tests. Strength tests, insitu compression, tension and direct shear tests. Pull out tests. Borehole extensometers, piezometers, embedment gauges, inclinometers, Slope indicators, packer tests for in-situ permeability, Codal provisions Standard penetration, plate load, static and dynamic cone penetration, field vane shear and pressure meter tests, Pile load tests, Pile integrity tests, Codal provisions, Laterally Loaded Piles, uplift capacity of piles. Processing of soil exploration data and its interpretation, instrumentation scheme for monitoring of critical sites

Suggested Books:

1. Bowles, J.E., (1997), Foundation Analysis and Design, McGraw-Hill International Edition"
2. Schnaid, F., (2008), "In Situ Testing in Geomechanics, Taylor and Francis"
3. Roy E. Hunt, (2005) "Geotechnical Engineering Investigation Handbook, Taylor and Francis"
4. Burt G. Look , (2014) "Handbook of Geotechnical Investigation and Design Tables, CRC press"

GTE 5405 Application of Remote Sensing & GIS in Geotechnical Engineering

Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS Various GIS packages and their salient features, Essentials components of GIS, Data acquisition through scanners and digitizers Raster and Vector Data: Introduction, Descriptions: Raster and Vector data, Raster Versus Vector, Raster to Vector conversion, Remote Sensing Data in GIS, Topology and Spatial Relationships, Data storage verification and editing Data pre-processing, Georeferencing, Data compression and reduction techniques, Run length encoding, Interpolation of data, Database Construction, GIS and the GPS, Data Output Database structure, Hierarchical data, Network systems, Relational database, Database management, Data manipulation and analysis Spatial and mathematical operations in GIS, Overlay, Query based, Measurement and statistical modelling, Buffers, Spatial Analysis, Statistical Reporting and Graphing, Application of GIS to various natural resources mapping and monitoring and engineering problems

Suggested Books:

1. Burrough, P.A. and Mc Donnel, R.A., (2000) "Principles of Geographic Information System", Oxford University Press.
2. Chrisman, Nicholas R., (2002) "Exploring Geographic Information Systems", John Wiley
3. Demers, Michael N., (2008)"Fundamentals of Geographic Information System", 2nd Ed. Wiley.
4. Ghosh, S.K. and Chandra, A.M., (2008) "Remote Sensing and GIS", Narosa Publishing House.
5. Lo, C.P. and Young, A.K.W., (2002) "Concepts and Techniques of Geographical Information System", Prentice Hall India.

GTE5407 Cost Management of Engineering Project

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation

Suggested Books:

1. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting (2003)
2. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
3. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd. (2015)

GTE5301 Geotechnical Earthquake Engineering

Introduction to engineering seismology, seismic risks and hazards, causes and strength of earthquakes, social and economic consequences, Theory of dynamic and seismic response, the nature and attenuation of earthquake magnitude, Ground motion, determination of site characteristics, local geology and soil condition, Determination of design earthquake, response spectra and accelerograms. Site response to earthquake site investigation and soil test; dynamic behavior of soils, liquefaction and cyclic mobility, analysis of pore pressure development In-situ test for liquefaction, analysis and design of slopes, embankments, seismic response of soil structure system, foundation Earth retaining structures for seismic loading, case histories, mitigation techniques

Suggested Books:

1. Steven Kramer, (2008) "Geotechnical Earthquake Engineering", Pearson
2. Naeim, F., (2001) "The Seismic Design Handbook, Kluwer Academic Publication, 2ndEdition,"
3. Ferrito, J.M, (1997) "Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme,"

GTE 5303 Stability Analysis of slopes

Slopes: Types and causes of slope failures, mechanics of slope failure, failure modes.

Stability analysis: infinite and finite slopes with or without water pressures; concept of factor of safety, pore pressure coefficients, Mass analysis, Wedge methods, friction circle method ; Method of slices, Bishop's method, Janbu's method, Morgenstern and Price, Spencer's method Stability analysis in the presence of seepage: two dimensional flow – Laplace equation and it's solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams, influence of seepage on slope stability stability analysis of dam body during steady seepage Strengthening measures: stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls, stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, instrumentation and monitoring of slopes, slope movements, warning devices, maintenance of slopes

Suggested Books:

1. Chowdhary R and Chowdharyl , "Geotechnical Slope Analysis", CRCPress. (2009)
2. Harr M.E.," Ground Water and Seepage", McGraw Hill. (1962)

GTE5305 Earth Pressure & Earth Retaining Structures

Earth Pressure: Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill. Retaining walls: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls

Sheet Pile wall: free earth system, fixed earth system Bulkheads: bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates. Tunnel and Conduit: Stress distribution around tunnels, Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations: Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays

Suggested Books

1. Das, Braja M., (1998) "Principles of Foundation Engineering", PWS Publishing
2. Bowles. J.E.,(1997) " Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn"

GTE5307 Pavement analysis and design

Philosophy of design of flexible and rigid pavements, Analysis of pavements using different analytical methods, Selection of pavement design input parameters – traffic loading and volume, Material characterization, drainage, failure criteria, reliability, Design of flexible and rigid pavements using different methods, Comparison of different pavement design approaches, design of overlays and drainage system.

Suggested Books:

1. Yang and H. Huang, (2004) "Pavement Analysis and Design, Pearson Prentice Hall"
2. Yoder and Witzech ,(1982) " Pavement Design, McGraw-Hill,"

GTE5201 SEMINAR

GTE5203 FEM in Geotechnical Engineering

Stress-deformation analysis: One dimensional, Two dimensional and Three-dimensional formulations

Discretization of a Continuum, Elements, Strains, Stresses, Constitutive, Relations, Hooke's Law, Formulation of Stiffness Matrix, Boundary Conditions, Solution Algorithms. Principles of discretization, element stiffness and mass formulation based on direct, variational and weighted residual techniques and displacements approach, Shape functions and numerical integrations, convergence Displacement formulation for rectangular, triangular and iso parametric elements for two dimensional and axisymmetric stress analysis.

Suggested Books:

1. O.C. Zienkiewicz and R.L. Taylor, (1992) "Finite element methods Vol I & Vol II, McGraw Hill,"
2. K.J. Bathe, (1996) "Finite element procedures, PHI Ltd.,"
3. David M Potts and Lidija Zdravkovic, (1999) "Finite Element Analysis in Geotechnical Engineering Theory and Apllication", Thomas Telford.

GTE5205 Offshore Geotechnical Engineering

Marine soil deposits: Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils Behavior of soils subjected to repeated loading: Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior

of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases Site Investigation in the case of marine soil deposits: Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits Foundations in marine soil deposits: Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations. cassions, spudcans Numerical modeling of marine foundations subjected to wave loading: Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading

Suggested Books:

1. H. G. Poulos. (1988) "Marine Geotechnics", Unwin Hyman Ltd, London, UK,
2. D. V. Reddy and M. Arockiasamy, (1991) "Offshore Structures", Volume: 1, R.E. Kreiger Pub and Co.
3. D. Thomson and D. J. Beasley, (2012) "Handbook of Marine Geotechnical Engineering", US Navy

GTE5207 Composite Material

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance. REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions. Introduction to manufacturing of Composites

Suggested Books

1. Hand Book of Composite Materials-ed-Lubin. (1982)
2. Composite Materials – K.K.Chawla (1987)
3. Composite Materials Science and Applications – Deborah D.L. Chung (2010)

SEMESTER II

Courses

GTE502 Rock Mechanics

Introduction ; problems of rock mechanics; classifications of rock masses Rock exploration – rock coring, geophysical methods; laboratory testing of rocks; fraction in rocks; elasticity & strength of rocks; strength & failure of rocks; Griffith's theory, Coulomb's theory, in-situ tests on rock mass; deformation characteristics, instrumentation and measurement of deformation of rocks; permeability. Mechanical, thermal and electrical properties of rock mass openings in rock mass and stresses around openings; pressure tunnels, development of plastic zone; rock support needed to avoid plastic deformation; lined and unlined tunnels; support pressure and slip of the joint; underground excavation and subsidence; foundation on rocks; bearing capacity of intact and jointed rocks; rock slopes; slope stability, rock bolt anchors & grouting Underground openings, pillars, tunnels, methods of construction; problems associated with tunnels, tunnelling in various subsoil conditions and rocks.

Suggested Books

1. Rock Mechanics Design in Mining and Tunellig, by Z.T. Bieniawski, (1984), Pub: A.A. Balkema
2. Engineering Rock Mass Classification by Z.T. Bieniawski,(1989).
3. Introduction to Rock Mechanics by R.E.Goodman,(1989)
4. Design and Construction of Tunnels by Pietro Lunardi Pub: Springer, (2008)
5. Engineering Rock Mechanics an Introduction to the Principles by Hudson and Harrision,(2000)

GTE504 Soil dynamics and machine foundation

Introduction, fundamentals of vibrations, vibration of elementary spring, mass, dashpot systems, degrees of freedom, Dynamic properties of geo-materials, wave propogation; Laboratory and field tests for evaluation of dynamic soil properties; vibration sensors. Vibration of foundations on elastic half space; design procedures for foundations with dynamic loads Dynamic stiffness of single pile and pile groups; Lumped parameter solutions, analysis and design of foundations for hammers, reciprocating engines and turbo generators Vibration isolation; retaining walls, small and large deformation problems, dynamic instrumentation.

Suggested Books

1. Das, B.M.,(1983) "Fundamentals of Soil Dynamics", Elsevier
2. Steven Kramer, (2008), "Geotechnical Earthquake Engineering", Pearson
3. Prakash, S., (1981), Soil Dynamics, McGraw Hill,
4. Kameswara Rao, N.S.V., (1998), "Vibration analysis and foundation dynamics,

GTE5402 Theoretical Soil Mechanics

Stresses and strains: elastic equilibrium analysis for plane strain and three dimensional cases. Effective stress, analysis of deformation and strain, state of stress and strain, constitutive relations, equilibrium and compatibility, general theorem. Drained and undrained loading, state boundary surface, plastic flow, yield and hardening, failure theorems for soils.Failures and plastic flow at critical state, associative and non-associative flow, residual strength; anisotropic compressions; ideal elastic behavior-two and three dimensional systems; theorems of plastic collapse Application to soil interaction, elasto- plastic theory of soil, rheological models; non linear viscoelasticity; problems and solutions.

Suggested Books:

1. Fundamental of Theoretical Soil Mechanics: ME Harr, (1966) (ISBN 978-0-070267411)
2. Elastic Solutions for Soils and Rock Mechanics :HG Poulos and EH Davis, (1974), (ISBN 9780471695653)
3. Theory of Elasticity & Plasticity: SP Timoshenko & JN Goodier (1982), (ISBN 978-0-9791865-0-9)
4. Critical State Soil Mechanics: AN Schofield & CP Wroth, (1968), (ISBN 978-0641940484)
5. Geotechnical Modelling: DM Wood ,(2004),(ISBN-978-0419237303)

GTE5404 Unsaturated soil mechanics

Introduction: Definition, scope, nature, moisture, pore pressure, and stress profiles, suction and potential of soil water, physical properties of unsaturated soilsSuction measurement and control, laboratory techniques, interfacial equilibrium: air-water-solid, vapour pressure, soil-water characteristic curve (SWCC), volume-mass relations. Capillarity and pore size distribution.State of stress, effective stress, strains, hysteresis, graphical representation of stress, stress state variables. Shear strength, extended Mohr-Coulomb criterion, shear strength parameters, constitutive modelling, and capillary cohesion.. Suction and earth pressure profiles, steady suction and water content profiles, earth pressure at rest, active earth pressure, and passive earth pressure. Flow through unsaturated soils, hydraulic conductivity functions, capillary barriers, infiltration and evaporation, vapour flow, air diffusion in water. Transient Flow, saturated and unsaturated, transient suction and moisture. Measurement of variables, suction measurement, hydraulic conductivity measurement, measurement of state variables: soil suction, total suction, osmotic suction, in-situ water content, measurement of SWCC. Triaxial testing of unsaturated soils

Suggested Books

1. "Unsaturated Soils: A fundamental interpretation of soil behaviour" by E. J. Murray and V. Sivakumar, Wiley – Blackwell, (2010).
2. "Unsaturated Soil Mechanics" by Ning Lu and William J. Likos, John Wiley & Sons, Inc.(2014)
3. "Unsaturated Soil Mechanics in Engineering Practice" by D. G. Fredlund, H. Rahardjo, and M. D. Fredlund, John Wiley & Sons Inc., (2012).

GTE5406 Critical state soil mechanics

Soil Behavior: State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiment. The Critical state line and the Roscoe surface: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces, The Roscoe surface Behavior of Over consolidated samples: The Hvorslev surface: Behaviour of over consolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes Behaviour of Sands: The critical state line for sands, Normalized plots, the effect of dilation, Consequences of Taylor's model Behaviour of Soils before Failure: Elastic and plastic deformations, Plasticity theory, Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified Cam-clay model

Suggested Books:

1. J. H. Atkinson and P. L. Bransby, (1978),"The mechanics of soils: An introduction to critical state soil mechanics", McGraw Hill
2. D. M. Wood, (1990) "Soil behaviour and critical state soil mechanics", Cambridge University Press,
3. B. M. Das, (2013)"Fundamental of geotechnical engineering", Cengage Learning,

GTE5408 Operational Research

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming. Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Suggested Books:

1. H.A. Taha, (2008), Operations Research, An Introduction, PHI,
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, (1982).
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, (2008
4. Hitler Libermann Operations Research: McGraw Hill Pub,(2009)

GTE5302 Minor Project

GTE5304 Soil Structure Interaction

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems. Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads. Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space. Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models. Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion. Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Suggested Books:

1. Tsudik, E. (2012)"Analysis of Structures on Elastic Foundations"- J. Ross Publishing
2. Wolf, J. P. (1985)"Dynamic soil-structure interaction"- Prentice Hall int..
3. Wolf, J. P., & Song, C. (1996) "Finite-element modelling of unbounded media"- Chichester: Wiley.
4. Kramer, S. L. (1996)"Geotechnical earthquake engineering (Vol. 80). Upper Saddle River"- NJ: Prentice Hall.
5. "Structure Soil Interaction" - State of Art Report, Institution of structural Engineers. (1978)

GTE5306 Disaster mitigation and management

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data. Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development

Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Suggested Books:

1. Chester, D. K. (1993),Natural hazards by EA Bryant. Cambridge University Press, 1991
2. Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014)," At risk: natural hazards, people's vulnerability and disasters. Routledge."
3. National Disaster Management Agency Documents, www. http://ndma.gov.in
4. Bommer, J. J. Earthquake protection: Andrew Coburn and Robin Spence, John Wiley & Sons, Ltd., Chichester, England, (2003)
5. Reiter, L. Earthquake hazard analysis: issues and insights. Columbia University Press.(1991)
6. Dowrick, D. J. Earthquake risk reduction. John Wiley & Sons. (2003)
7. Aki, K., & Richards, P. G. Quantitative Seismology: Theory and Methods. Volume I: WH Freeman & Co.(1980)
8. FEMA Documents, http://www.fema.gov
9. Mileti, D. Disasters by Design:: A Reassessment of Natural Hazards in the United States. Joseph Henry Press.(1999)
10. Bryant, E. A. Natural Hazards, © Cambridge University Press.Cambridge, New York,Melbourne. (2005)

GTE5308 Uncertainties, risk and reliability in Geotechnical Engineering

Risk, terminology, randomness, uncertainty, Basic Concept of Reliability, Measures of Reliability, Sources of Uncertainty, Steps in the Modeling of Uncertainty. Modeling of Uncertainty: Descriptors of Randomness, Histogram and Frequency Diagram, Analytical Models to Quantify Randomness, Introduction to probability. Commonly Used Probability Distributions, Determination of Distributions an Parameters from Observed Data, Interval estimation of Mean and Variance, Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test), Modeling random variables like loads, material properties etc. Reliability method: Introduction, Deterministic and Probabilistic approaches, basic variables and failure surface, first order second moment methods (FOSM).Simulation Methods: Basis of simulations methods, random number generation. concept of Monte Carlo simulation and applications, Practical reliability analysis and design by Monte Carlo Simulation. System reliability: Series, parallel and mixed system, Modelling of structural system. Risk assessment, Probabilistic risk assessment Application to Civil engineering problems using MATLAB

Suggested Books:

1. Haldar, A., and Mahadevan, S. (2000),"Probability, reliability and statistical methods in engineering design." John Wiley and Sons, New York.
2. J R Benjamin and C A Cornell, (1970), "Probability, statistics and decisions for civil engineers" John Wiley, New York.
3. A Papoulis, "Probability, random variables and stochastic processes" 3rd Edition, McGraw-Hill, New York. (1991).

GTE5202 Ground water hydrology

Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity. Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, Multiple Well Systems, Partially Penetrating Wells, Well for special Conditions, Characteristics Well Losses, Specific Capacity Surface investigation of Ground water: Geologic methods, Remote sensing, geophysical exploration, Electric resistivity Method, Seismic Refraction Method, Gravity and Magnetic Methods, Water Witching. Concept of Artificial Recharge of Ground water, recharge methods, research on water spreading, Wastewater recharge for reuse, Recharge Mounds. Artificial Recharge on long Island, New York, Include Recharge, artificial Recharge for Energy purposes. Groundwater Flow Modelling: Porous media models, Analog models, Electric Analog Models and Digital computer models.

Suggested Books:

1. Todd, D.K., "Groundwater Hydrology", John Wiley. 1959
2. Bear, J., "Hydraulics of Groundwater", McGraw. 1979
3. Bouwer, H., "Groundwater Hydrology", McGraw Hill. 1978
4. Walton, W.C., "Groundwater Resources Evaluation", McGraw Hill. 1970
5. Freeze and Cherry, "Groundwater", Prentice Hall. 1979

GTE5204 Physical Modelling in Geomechanics

Introduction to modelling, empirical models, theoretical models, numerical modelling, constitutive modelling, physical models, geological model, classification model Physical modelling, dimensional analysis, scaling laws, Gravity modelling Introduction to constitutive modelling, theoretical modelling and centrifuge modelling

Suggested Books:

1. David wood, Geotechnical Modelling, CRC press (1999).
2. M. B. C. Ulker and M. Safiur Rahman, Modeling and Computing for Geotechnical Engineering: An Introduction, CRC press, (2018).

GTE5206 Numerical and Analytical Method in Geomechanics

Solution of Non-linear Equations: Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods, Solution of Linear Equations: Jacobi's method, Gauss Seidal method, Successive over relaxation method. Finite Difference Method: Two point Boundary value problems – Disichlet conditions, Neumann conditions; ordinary and partial differential equations. Finite Element Method: Fundamentals, Constitutive finite element models for soils. Correlation and Regression Analysis: Correlation - Scatter diagram, Karl Pearson coefficient of correlation, Limits of correlation coefficient; Regression –Lines of regression, Regression curves, Regression coefficient, Differences between correlation and regression analysis. One-dimensional Consolidation - Theory of consolidation, Analytical procedures, Finite difference solution procedure for multi layered systems, Finite element formulation, Flow Through Porous Media - Geotechnical aspects, Numerical methods, Applications and Design analysis, Flow in jointed media.

Suggested Books:

1. S. Chandrakant., Desai and John T. Christian, "Numerical Methods in Geotechnical Engineering", Mc. Graw Hill Book Company, (1977)
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineering computations", Third edition, New Age International (P) Ltd. Publishers, New Delhi. (2008)
3. D.J. Naylor and G.N. Pande, "Finite Elements in Geotechnical Engineering", Pineridge Press Ltd., UK. (1981)

GTE5208 Waste to Energy

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical

conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Books:

1. Desai, A. V. (1990) " Non Conventional Energy" - Wiley Eastern Ltd.
2. Khandelwal, K. C. and Mahdi, S. S. (1983) "Biogas Technology - A Practical Hand Book" (Vol. I & II) - Tata McGraw Hill Publishing Co. Ltd.
3. Challal, D. S. (1991) "Food, Feed and Fuel from Biomass" - IBH Publishing Co. Pvt. Ltd.
4. WereKo-Brobby, C.Y. and Hagan, E. B. (1996) "Biomass Conversion and Technology"- John Wiley & Sons.

SEMESTER III

Courses

GTE 651 Research Project

GTE 601 Major Project 1

GTE 6401 Plasticity & fracture Mechanics in Rock Structures

Introduction of plasticity, linear elasticity, nonlinear elasticity, hyper elasticity, hypo elasticity, hypo elasticity, Two and three dimensional stress analysis, stress invariants, octahedral stresses; small and large deformations, finite strains - Euler & Langragian approaches, Green's & Cauchy's strain tensors; Yield criteria: Von Mises, Tresca, Mohr-Coulomb, Drucker-Prager, Modified Mohr-Coloumb, Lade Duncan, Matsuoka Nakai model, Hoek & Brown yield criteria; Isotropic, Kinematic and mixed hardening, softening normality principle, plastic flow rule, plastic potential, Cam-clay, plastic stress-strain relations: stress path dependent behavior, generalised elasto-plastic stress-strain relations, insitu hardening and softening modulus. Crack phenomenon and mechanics of brittle fracture propagation, elementary theories of crack propagation, cracks in elasto-plastic media, Constitutive equations for rocks – Class I and Class-II materials, uniaxial and triaxial stress conditions in tension, Compression and shear, size effects, representative size of specimen;Continuum characterization of jointed rock mass, constitutive equations for discontinuities – Joint stiffnesses and shear strength, Application of fracture mechanics to underground opening, rock stabbing, bursting and hydraulic fracturing.

Suggested Books:

1. Miannay Dominique P, Fracture Mechanics, Publisher: Springer-Verlag New York Inc.
2. Brocks, Wolfgang, Plasticity and Fracture, Springer, (2018)
3. H. P. Rossmanith, Rock Fracture Mechanics, SPRINGER VERLAG GMBH, (2004).

GTE 6403 Theory of elasticity and plasticity in Geomechanics

Theory of Elasticity: Stress tensor, equations of equilibrium.. Kinematic relationships and equations of compatibility. Generalized Hooke's Law Boundary conditions. Plane stress, plane strain, Airy's stress function. Saint Venant's principle. Problems in rectangular and polar co-ordinates; inverse and semi-inverse methods; torsion of Prismatic bars members analogy; typical applications. Theory of

plasticity; hydro-static and deviatoric components of stress tensor; invariant of stress tensors; Von Misses yield conditions; octahedral stresses. Analysis of Bending of bars of narrow rectangular cross section-formation of Plastic hinge, Torsion of prismatic bars-sand-heap analogy, Thick spherical shell-bursting pressure, Thick cylindrical tube.

Suggested Book:

1. Timoshenko, S. P., & Goodier, J. N. (1971),"Theory of Elasticity"- McGraw-Hill, New York
2. Shames, I. H.(1964), " Mechanics of deformable solids"- Prentice Hall
3. Srinath, L. S. (2003),"Advanced mechanics of solids"- Tata McGraw-Hill.
4. Chakrabarty, J.(2012), "Theory of plasticity" - Butterworth-Heinemann.
5. Popov, E. P., & Balan, T. A. (1968), " Mechanics of solids" - Pearson Education.

GTE 6405 Design of underground/ sub structures

Introduction : Substructure- Definition and purpose, role of foundation engineer Basic soil input parameters for foundation design: Foundation Deign: General Principles Type of foundations, selection of type of foundation Basic requirements, computation of loads, Limit state Design: Basic principles shallow foundations: type and their selection conventional method of design, Beams of elastic foundation and finite difference method of analysis, Structural design of footings and rafts, foundations subjected to eccentric- inclined loads, footing in seismic zones: pile foundations: type, construction techniques, proportioning of pile foundations: ;pads/ forces considered for structural design, structural design of deep/ pile foundations for a multistoried buildings subjected to dynamic loads: Bridges sub structure - forces on bridges foundation (IRC & IS specifications) design of piers, abatements & wing walls, well foundation components, stability analysis, designing of various components, materials for construction,, sinking of well Placing of curb, dredging and jetting: marine substructures: type, breakwaters, wharves, Sea walls, design and construction methods, foundations of transmission line towers, forces on tower foundation, general design criteria, choice & type of foundation, testing and design procedures. Tunnels, openings, design and construction methods, general design criteria, choice & type of tunnels and openings, testing and design procedures.

Suggested Books:

1. Swami Saran, Analysis and Design of Substructures: Limit State Design, Oxford & IBH Publishing Company Pvt. Limited, (2006)
2. Paul Andersen , Substructure analysis and design, Ronald Press; 2 nd edition (1958)
3. Wyllie Duncan C.," Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis.
4. Petros P. Xanthakos, Bridge Substructure and Foundation Design 1st Edition
5. Design and Construction of Tunnels by Pietro Lunardi Pub: Springer, (2008)

GTE 6407 Structural Geology

Origin, interior and composition of the earth. Rock cycle, Igneous, Metamorphic and Sedimentary rocks. Rock structures. Plate tectonics, Continental drift and sea floor spreading. Geological time scale. Layered formations, Attitude, true and apparent dips, topographic maps, cutcrops. Measurement of attitude of formations. Folds, types of folds, classification, field study of folds, mechanics of folds, causes of folding. Joints, rock mass concept, Joint description and classification. Three-point problems, Depth and thickness problems. Faults, mechanics of faulting, normal, reverse and thrusts,

faults. Lineation's. Foliations, Schistocity. Fault problems. Stereographic projection methods, Use of DIPS software, presentation of geological data and analysis, Applications, Scan line survey of rock joints in the visit

Suggested Books :

1. Marland P. Billings, Structural Geology, (2008)
2. Haakon Fossen , Structural Geology.(2016)
3. Donal M. Ragan , Structural Geology: An introduction to Geometrical Techniques.(2009)

GTE 6301 Geosynthetic

Introduction; Basic Description; Polymeric Materials; History and Manufacture of Geotextiles, Geogrids, Geonets, Geomembranes, Geofoam, Geosynthetic Clay Liners, and Overview of Geocomposits. Geotextiles: functions and mechanisms, properties and test methods, geotextile properties, use for separation, use for soil reinforcement, use for filtration, use for drainage, multiple functions, installation survivability. Geosynthetic Clay Liners (GCLs): properties and test methods, GCLs as single and composite liners, GCLs as covers, GCLs on slopes, construction methods. Geofoam: properties and test methods, various design applications, construction methods. Geogrids: properties and test methods, geogrid reinforcement for various purposes, construction methods. Geonets: properties and test methods, geonet applications, construction methods.Geocomposits: applications in separation, reinforcement, filtration, and drainage. Geogrids: properties and test methods, geogrid reinforcement for various purposes, construction methods. Geonets: properties and test methods, geonet applications, construction methods. Geomembranes: properties and test methods, use as liquid containment liners, use as covers for reservoirs and quasi-solids, use as canal liners, use as landfill liners, use as landfill covers and closures; applications in: underground storage tanks, dams, tunnels and cutoff walls; geomembrane seams

Suggested Books :

1. "Designing with Geosynthetics Vol. 1 & 2" by Robert M. Koerner, Xlibris Corporation.(2012)
2. "An Introduction to Soil Reinforcement and Geosynthetics" by G. L. Sivakumar Babu, University Press (India) Private Limited (2006).

GTE 6303 Ground Improvement Techniques

Introduction: importance and history of ground improvement. Mechanical Modifications: properties of compacted soil, compaction control tests, field compaction, applications. Precompression: technique, procedure, and applications. Sand Drains: method, procedure and application Prefabricated vertical drains: method of installation and design. Soil Stabilisation: shallow stabilisation with additives like lime, fly ash, cement and other materials. Chemical modifications and Grouting. Hydraulic modification: dewatering systems, filtration, drainage and seepage control with geosynthetics.Vibroflotation technique, stone columns, sand compaction piles, dynamic compaction technique, ground freezing, and electro-osmosis.Ground modification by soil reinforcement: reinforcement techniques, use of flexible geosynthetic reinforcement in bearing capacity improvement, slope stability, erosion control, retaining walls and pavements.Difficult soils: collapsible soils, physical parameters and identification, collapse settlement, improvement techniques; expansive soils, general nature, swell test and swelling pressure tests, classification, improvement of expansive soils.

GTE 6305 Excavation Technology

Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi'selasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies

Suggested Books :

1. Das, B. M. (2011) Principles of Foundation Engineering. Cengage Learning.
2. Koerner, R. M. (2012) Designing with Geosynthetics, Vol. 1 & 2. Xlibris Corporation.
3. Moseley, M. P., Kirsch, K (2004). Ground Improvement. Spon Press.

GTE 6307 Probability & Statistical Methods in Engineering

Preliminary data analysis: Graphical representation of data (stem and leaf plot, box plot, Q-Q Plots), frequency distribution, measure of central tendency-grouped and ungrouped data, measure of dispersion, measure of asymmetry, measure of peakedness, covariance, correlation coefficient. Random events: Sample space and events, Interpretation of probability, Probability axioms, Elementary theorems, conditional probability, Bayes' theorem. Random Variables: Definition of random variables - discrete and continuous; Probability definitions - PMF, PDF, CDF; Moments and expectations. Concept of risk and reliability. Probability Distributions: Discrete distributions - binomial distribution, Poisson's distribution; Continuous distributions – uniform distribution exponential distribution, gamma distribution, Weibull, Normal and lognormal distributions. Extreme value distributions, Multivariate distribution-Bivariate Normal distribution, other bivariate distribution, Transformations to Normal distribution. Model Estimation and Testing: Properties of estimators, sampling distributions-Chi square distribution, t-distribution, F distribution, Parameter estimation-Point estimation, confidence interval estimation, Hypothesis testing-Tests of hypotheses on the mean and variance, Goodness-of-fit tests, fitting theoretical distributions to observed frequency distributions and Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test). Curve fitting: method of least squares, simple linear regression, coefficient of correlation and the sample correlation, multiple linear regression. Principal component analysis. Case study of Monte Carlo simulation.

Suggested Books :

1. Haldar, A., and Mahadevan, S. (2000) "Probability, reliability and statistical methods in engineering design." - John Wiley and Sons, New York.
2. Benjamin J. R and Cornell C .A , (1970) "Probability, statistics and decisions for civil engineers", - John Wiley, New York.
3. Papoulis A , (1991) "Probability, random variables and stochastic processes", 3rd Edition, - McGraw-Hill, New York.
4. Ross S.M , (2004) "Introduction to Probability and Statistics for Engineering and Scientist" - Academic Press, Elsevier

GTE 6201 Design of underground excavations

Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design.Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theoryApplication of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels an caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.Rock mass-tunnel support interaction analysis. ground response and support reaction curves, Ladanyi'selasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies

Suggested Books :

1. Hoek, E and and Brown, E. T.,(1980) " Underground Excavations in Rocks", Institute of Mining Engineering.
2. Obert, L. and Duvall, W.I., "Rock Mechanics and Design of Structures in Rocks", John Wiley (1967)
3. Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier. (1999)
4. Singh, B. and Goel, R.K., "Tunnelling in Weak Rocks", Elsevier (2006)

GTE 6203 Foundation on Weak rocks

Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests, Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and inelasticity Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behaviour of bored / driven piles in soft / weathered rocks

Suggested Books :

1. Wyllie Duncan C.," Foundations on Rock: Engineering Practice", E&FN Spon, Taylor and Francis. (1999)
2. Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford
3. Singh, B. and Goel, R.K.,"Rock Mass Classification- A Practical Engineering Approach", Elsevier .(1997)
4. Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvi. Ltd. (2014)

GTE 6205 Geotechnical Design Studio

Seepage analysis through an earth dam. Slope stability analysis of a dam. Settlement analysis of shallow and deep foundations; Analysis and design of retaining structures; Analysing the structural forces in a tunnel lining.

Suggested Books :

1. M.S.Rahman and M.B.Can Ulker Modeling and Computing for Geotechnical Engineering, (2018)
2. Donald P. Coduto , Foundation Design Principles and Practises, (1999)
3. Robert D. Haltz, WilliaM D kavacs and Thomas C. Shealen:An Introduction to Geotechnical Engineering (1981)

SEMESTER IV

Courses

GTE 652 Research Project

GTE 602 Major Project II

DEPARTMENT OF CIVIL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Hydraulics & Water Resources Engineering)

Programme Specific Outcomes

Post graduate student will have

1. Fundamental and contemporary knowledge necessary to analyze problems associated with ware water resources, fluid mechanics and hydraulic Engineering.
2. Ability to think originally, and to conceptualize and provide potential solutions to problmes in the context of global, societal and cultural domains.
3. Flair for research and development in the global scenario, with the ability to present and communicate technical findings.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN HYDRAULICS & WATER RESOURCES ENGINEERING (HWE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year), C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	HWE501	Computational Hydraulics	Core	4	3	0	2	15	25	20	40	-	17
	2	HWE503	Advanced fluid Mechanics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	HWE5401/5403/..	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	HWE5301/5303/..	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	HWE5201/5203/../ UEC5201/5203/.	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	HWE502	Water Resources Systems Planning and management	Core	4	3	0	2	15	25	20	40	-	17
	2	HWE504	Advanced open channel Hydraulics	Core	4	3	0	2	15	25	20	40	-	
Group D	3	HWE5402/5404/..	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	HWE5302/5304/..	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	HWE5202/5204/../ UEC5202/5204/	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	HWE651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	HWE601	Major Project I	Core	3	0	0	6			40	60	0	
	2	HWE6401/6403/...	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	HWE6301/6303/...	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	HWE6201/6203/...	Elective 9	Elective	2	2	0	0	20	-	30	50	0	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													12
	1	HWE652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	HWE602	Major Project II	Core	12						0	100	0	

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	HWE5401	Advanced Hydrology	Elective	4	3	0	2	15	25	20	40	-
	2	HWE5403	Environmental Hydraulics		4	3	0	2	15	25	20	40	-
	3	HWE5405	Coastal Engineering		4	3	0	2	15	25	20	40	-
	4	HWE5407	Systems Engineering		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	HWE5301	Water Power Engineering	Elective	3	3	0	0	20	0	30	50	-
	2	HWE5303	Geotechnical Earthquake Engineering		3	3	0	0	20	0	30	50	-
	3	HWE5305	Sediment Transport		3	3	0	0	20	0	30	50	-
	4	HWE5307	Water and Soil Conservation Engineering		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	HWE5201	Seminar	Elective	2	0	0	2	-	0	-	100	-
	2	HWE5203	Environmental System Modelling		2	2	0	0	20	0	30	50	-
	3	HWE5205	Engineering Risk Analysis		2	2	0	0	20	0	30	50	-
	4	HWE5207	Urban Water Infrastructure		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	HWE5402	Design of Flood Control and River Training Works	Elective	4	3	0	2	15	25	20	40	-
	2	HWE5404	Irrigation and Drainage Engineering		4	3	0	2	15	25	20	40	-
	3	HWE5406	Hydrometeorology		4	3	0	2	15	25	20	40	-
	4	HWE5408	Hydro-informatics and Simulations		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	HWE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	HWE5304	Applications of GIS and Remote Sensing in Water Resources Engineering		3	3	0	0	20	0	30	50	-
	3	HWE5306	Soil Structure Interaction		3	3	0	0	20	0	30	50	-
	4	HWE5308	Disaster Mitigation and Management		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	HWE5202	Ground Water Hydrology	Elective	2	2	0	0	20	0	30	50	-
	2	HWE5204	Transients in Pipes		2	2	0	0	20	0	30	50	-
	3	HWE5206	Offshore Geotechnical Engineering		2	2	0	0	20	0	30	50	-
	4	HWE5208	Waste to Energy		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	HWE6401	Design of Hydraulic Structures	Elective	4	3	0	2	15	25	20	40	-
	2	HWE6403	Environmental Impact Assessment		4	3	0	2	15	25	20	40	-
	3	HWE6405	Water pollution control and stream Sanitation		4	3	0	2	15	25	20	40	-
	4	HWE6407	Stability Analysisof Slopes		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	HWE6301	Geosynthetics	Elective	3	3	0	0	20	-	30	50	-
	2	HWE6303	Ground Improvement Techniques		3	3	0	0	20	-	30	50	-
	3	GTE6305	HWE6305		3	3	0	0	20	-	30	50	-
	4	GTE6307	HWE6307		3	2	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	2	HWE6201	Subsurface Investigations		2	2	0	0	20	-	30	50	0
	3	HWE6203	Introduction to AI Techniques		2	2	0	0	20	-	30	50	0
	4	HWE6205	Geotechnical Practice for Waste Management System and Ground modifications		2	2	0	0	20	-	30	50	60

SEMESTER I

Courses

HWE501 Computational Hydraulics

Introduction to Computational Fluid Dynamics and Principles of Conservation: Continuity Equation, Navier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behaviour. Approximate Solutions of Differential Equations: Error Minimization Principles, Variational Principles and Weighted Residual Approach, Fundamentals of Discretization: Finite Element Method, Finite Difference and Finite Volume Method, Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and Discretization of Unsteady State Problems, Important Consequences of Discretization of Time Dependent Diffusion Type Problems.

Stability Analysis: Consistency, Stability and Convergence, LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes. Finite Volume Discretization of 2-D Unsteady State Diffusion Type Problems, Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Gradient Search Methods. Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations: Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation, Introduction to Turbulence Modelling.

Suggested Books:

1. Anderson, Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 1984.
2. T. J. Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill, 1978.
3. Anderson, & Weessner, Applied Groundwater Modelling , Academic Press, 1992.
4. H. M. Chaudhary, Applied Hydraulic Transient, McGraw Hill, 1976.
5. Streeter and Wylie, Fluid Transients, McGraw Hill, 1976.

HWE503 Advanced Fluid Mechanics

Kinematics of Flow: Equation of continuity in Cartesian, polar and cylindrical coordinates, Standard 2D Flow Patterns: Source, sink, doublet and their combinations, construction of flows by superposition, D'Alembert's paradox. Modelling and dimensional analysis: Introduction, Dimensional Homogeneity Methods of Dimensional analysis, Model Analysis like types of similarity, Types of forces acting on moving fluids, Dimensionless numbers, Classification of models and Model laws.

Laminar Flow: Derivation of Naiver-Stokes equations – exact solutions for flow between parallel plates, Couette flow, flow near a suddenly accelerated plate and an oscillating plate. Boundary Layers: introduction, types of boundary layer Drag force on Flat plate due to boundary layer analysis of turbulent boundary layer, separation in boundary layer under adverse pressure gradient and methods of preventing of the separation of boundary layer. Fundamentals of compressible flows: Introduction, Thermodynamics Relations. Basic equations of compressible flow, velocity of sound or pressure wave in a fluid, Mach number.

Suggested Books:

1. F.M. White, Fluid Mechanics, McGraw-Hill, 1979.
2. H. Schlichting, Boundary Layer Theory, McGraw-Hill, 1979.
3. R.J. Garde, Turbulent Flow, Wiley Eastern Limited, 1994.
4. S. B. Pope, Turbulent Flows, Cambridge University Press, 2000.
5. H. Rouse , Advanced Mechanics of Fluids, John Wiley and Sons, 1959.

HWE5401 Advanced Hydrology

Introduction: Hydrologic system and hydrologic budget, fundamental laws of hydrology; atmospheric water vapour. Hydrologic Inputs: Precipitation and its forms, snowfall and rainfall; measurement techniques and space-time characteristics. Hydrologic Abstractions: Infiltration, depression storage, evapotranspiration; measurement techniques, space time characteristics and their modelling. Stream flow: Measurement techniques, space-time characteristics, rating curves System Approach: Unit Hydrograph IUH, GIUH. Mathematical Modelling: Linear and Nonlinear models, Physically based models. Hydrological routing, Flood forecasting. Advanced Method of Frequency Analysis: Outliers, Time series analysis. Impact of climate change and Land use/Land cover on basin response.

Suggested Books:

1. V.T. Chow, D.R. Maidment and W.L. Mays, Applied Hydrology, McGraw Hill, 1988.
2. C.S.P. Ojha, R. Berndtsson and P. Bhunya, Engineering Hydrology, Oxford University Press, 2008.
3. M. Wanielista, R. Kersten and R. Eaglin, Hydrology, John Wiley, 1997.

HWE5403 Environmental Hydraulics

Introduction and scope, review of basic principles of engineering fluid mechanics, continuity, momentum, and energy equations, steady flow through pipes- hydraulic gradient and total energy line, basics of open channel flow; Ground water, well hydraulics, well design and constructions, Parallel, compound and equivalent pipes, head losses in pipes, design of pressurized Conduits. Various forms of mixing in the environment, modeling of the mixing process: advection dispersion equation, Various forms of advection dispersion eq. and its solution. Special cases of mixing, density stratified flow, tide, etc. Mass transfer in gas-liquid and liquid -liquid system with special emphasis on aeration

Suggested Books:

1. J.A. Roberson, J.J. Cassidy, M.H. Chaudhry, Hydraulic Engineering, 2nd Edition, Wiley, 1998.
2. A. Chadwick, J. Morfett, M. Borthwick, Hydraulics in Civil and Environmental Engineering, 5th Edition, CRC Press, 2004.
3. C. C. Lee, S.D. Lin, Handbook of Environmental Engineering Calculations, McGraw Hill, 2007.
4. J.L. Schnoor, Environmental Modeling: Fate of Chemicals in Water, Air and Soil, John Wiley & Sons, New York, 1996.

HWE5405 Coastal Engineering

Definition-wave classification-linear theory of waves-assumptions and derivations of relationship of wave characteristics-pressure within a progressive wave, wave energy, energy flux-wave. Decay-Transformation of Waves-Fundamental aspects of stokes theory. Reflection, Refraction, Diffraction of Wave-Breaking of waves-types, criterion and importance of breaking- wave force on structure-vertical, sloping, curved and stepped barrier-force due to non-breaking, breaking and broken Waves-Force on piles. Need for forecasting- SMB and PNJ methods of wave forecasting. Origin and classification of tides Karwin's equilibrium, theory of tides-effects on structure-seiches and teunamis. Types of sediment and movement-types of beaches and beach profile. Long Shore drift and its engineering significance. Causes of coastal erosion and methods of protection.

Suggested Books:

1. R. M. Sorensen, Basic Coastal Engineering, Chapman & Hall, New York, 1997.
2. A. Wantanabe, M. Isobe, & N. Kraus, International Handbook Of Coastal Engineering and Management, Academic, 1999.
3. R. L. Wiegel , Oceanographical Engineering, Prentice-Hall, 1964.
4. R. Silvester, Coastal Engineering, Elsevier, 1974.

HWE5407 Systems Engineering

Definitions and components of a system, system control, systems modelling and model development. System synthesis, economic analysis. Conflicts and role of optimization in Systems resolution. Unconstrained optimization –analytical and numerical. Constrained optimization analytical and numerical. Integer programming. Geometric programming. Linear programming. Dynamic programming. Stochastic programming.

Suggested Books:

1. R.J. Aguilera, Systems Analysis and Design, Prentice Hall, 1973.
2. P. J. Ossenbruggen, Systems Analysis for Civil Engineering, John Wiley, 1984.
3. R. De Neufrille, Systems Analysis for Engineer, McGraw Hill, 1971.
4. S.S. Rao, Engineering Optimization – Theory and Practice, New Age International Ltd, 1999.

HWE5301 Water Power Engineering

Introduction: Development of water power, Estimation of Hydropower potential, Comparison of Hydro, thermal and nuclear power, Flow duration curve, firm power, secondary power, Load and Load duration curves, Load factor, etc. Types of Hydropower Plants: Classification of hydropower plants, Run-of-river plants, Valley dam plants, High head diversion plants, Diversion Canal plants, Pumped storage plants, Tidal power plants. Water Conveyance System: Power canals, Alignment, Design of power canals, Flumes, Covered conduits and tunnels, Drainage and ventilation in tunnels. Penstocks: - Alignment, types of penstocks, economic diameter of penstocks, Anchor blocks. Fore bay, Intakes, Balancing Reservoir, Escape, Surge Shafts/ Inclined Shafts. General Layout of power house and arrangement of hydropower units. Underground Power Stations.

Dams: Selection of site, preliminary investigations, Final investigations, Types of dams: - Rigid dams, Gravity dams, Arch and buttress dams, Basic principles of design and details of construction.

Earthen dams, rock fill dams, Design considerations. Spillways: Types, spillway gates, Design of stilling basins. Types of Turbines and their utility: Hydraulic Turbines, Classification Based on Head, Discharge, Turbines, Differences between Impulse and Reaction Turbines, choice of Type of Turbine-Specific Speed. Component Parts & Working Principles of a Pelton Turbine and Francis Turbine.

Suggested Books:

1. D.P. Loucks , J.R. Stedinger, and D.A. Haith , Water Resources Systems Planning and Analysis, 1st Ed., Prentice Hall, 1981.
2. C.S. ReVelle , E.E. Whitlatch Jr and J.R. Wright, Civil and Environmental Systems Engineering, Pearson Prentice Hall, 2004.
3. L.D. James and R.R. Lee, Economics of Water Resources Planning, McGraw-Hill, 1971
4. A. A. Smith, E. Hinton and R.W. Lewis, Civil Engineering Systems Analysis and Design, John Wiley and Sons, 1983.

HWE5303 Geotechnical Earthquake Engineering

Introduction to engineering seismology, seismic risks and hazards, causes and strength of earthquakes, social and economic consequences, Theory of dynamic and seismic response, the nature and attenuation of earthquake magnitude, Ground motion, determination of site characteristics, local geology and soil condition, Determination of design earthquake, response spectra and accelero-grams Site response to earthquake site investigation and soil test; dynamic behaviour of soils, liquefaction and cyclic mobility, analysis of pore pressure development In-situ test for liquefaction, Analysis and design of slopes, embankments, seismic response of soil structure system, foundation, Earth retaining structures for seismic loading, case histories, mitigation techniques.

Suggested Books:

1. Steven Kramer, Geotechnical Earthquake Engineering, Pearson, 1996.
2. F. Naeim, The Seismic Design Handbook, Kluwer Academic Publication, 2ndEdition, 2001.
3. J.M Ferrito, Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme, 1997.

HWE5305 Sediment Transport

Introduction of sediment transport, sediment problems, properties of sediments, incipient motion of uniform and non-uniform sediments. Bed forms and channel resistance. Bed load and suspended load transport for uniform and non-uniform bed material, total load equations, sediment sampling. Stable channel design and sediment control. Bed level variations, local scour, degradation, aggradation and reservoir sedimentation. Physical and mathematical models. Design of guide bunds and other river training banks.

Suggested Books:

1. R.J. Garde, River Morphology, New International Publishers, 2006.
2. P.Y. Julien , Erosion and Sedimentation, Cambridge University Press, 1998.
3. P.P.H. Jansen , Principals of River Engineering, VSSD Publications, 1994.
4. R.J. Garde and K.G.R. Raju , Mechanics of Sediment Transportation and Alluvial Stream Problems, Wiley Eastern Limited, 2006.

HWE5307 Water and Soil Conservation Engineering

Water conservation: Rain water harvesting techniques, water shed development, ground water recharging, check dams, reservoirs and aquifers, Control of infiltration, seepage and evaporation, control of effluent and waste water disposal, control of agricultural runoff and siltation. Plan utilisation of water resources, flood plains zone management, reuse and recycling of treated waste water, effluent irrigation. Soil Conservation:_Introduction to soil erosion, mechanisms and its causes and control, sheet erosion, rill erosion, gully erosion, control of erosion by bunding, terracing, contour trenching, gully stabilizing, check dams, drop spillways, chute spillways. Grass land management and forest management, reclamation of saline and usher soils, remediation of contaminated soils.

Suggested Books:

1. Soil survey manual - All India soil & land use survey organization.
2. Soil taxonomy, basic system of soil classification for making & interpreting soil survey, Agriculture Handbook No. 36, Nbss & Lup Publication New Delhi.
3. Soil & water conservation engineering by Schwab, Fravert Edminster & Barnes John Wiley and Sons Publication.
4. Soil conservation in India I.C.A.R. New Delhi, Ramarao, M.S.V. - 1962.

HWE5201 Self-Study Open Area Seminar

HWE5203 Environmental System Modelling

Introduction to natural and manmade systems, managerial requirements. Application of package programmes such as dBASE, GIS in data base management, Operational aspects and environmental auditing. Determinate and structure modelling applications: Models of waste collection systems and treatment systems, models of water quality and contamination, models of solid waste collections.

Suggested Books:

1. R.V. Thomann and J.A. Mueller, Principles of Surface Water Quality Modelling and Control, Harper and Row,1987.
2. Chapra, C. Steven, Surface Water Quality Modelling, Mc Graw Hill, 1997.
3. Hammer, J. Mark, Water and Wastewater Technology, John Wiley, 1977.
4. H.S. Peavy, R.R. Donald and G. Tchobanoglous, Environmental Engineering, Mc Graw Hill, 1986.

HWE5205 Engineering Risk Analysis

Application of probability theory and statistics in planning, analysis and design of civil engineering systems. Development of probabilistic models for risk and reliability evaluation, occurrence models, extreme value distributions. Analysis of uncertainties, introduction to Bayesian statistical decision theory and its application in engineering. Decision making. Risk evaluation and management of engineering systems.

Suggested Books:

1. A. Hoyland, and M. Rausand, System Reliability Theory. Hoboken, NJ: Wiley-Interscience, 1994.
2. H. Tehler, A general framework for risk assessment, Department of Fire Safety Engineering and Systems Safety, Lund University, Sweden, 2013.

3. G. Apostolakis, How Useful is Quantitative Risk Assessment, 2004.

4. Institute of Chemical Engineers, Guidelines for Chemical Process Quantitative Risk Analysis, New York, 2000.

HWE5207 Urban Water Infrastructure

Urban water cycle, Urban water infrastructures - water supply, storm water drainage, sanitation, sewerage and wastewater conveyance infrastructures. Water supply and sewerage network hydraulics, SCADA systems, Sustainable urban designs, Methodologies for assessing sustainability of urban water infrastructures, Emerging sustainable materials and design procedures for water supply and sewerage pipelines. Hydraulic performance and structural strength, chemical resistance and resilience characteristics of emerging materials based water and sewer pipelines, Rehabilitation and augmentation technologies for water supply and sewerage networks, Analytic hierarchy process and optimization techniques for arriving at the best appropriate rehabilitation/ augmentation technology. Urban water management, Rain water harvesting, Managed aquifer recharge, Constructed/engineered wetlands, Sprinkler and drip irrigation, Water use efficiencies, Effect of water management practices on urban water infrastructure. Hydrology and groundwater regime, Surface and subsurface mapping of water supply and sewerage networks, Structural safety and mitigating plans against natural and human caused threats.

Suggested Books:

1. N.S. Grigg, Water, Wastewater, and Storm water Infrastructure Management, Second Edition, CRC Press, 2012.

2. T.R. Lazaro, Urban Hydrology, CRC Press, 1990.

3. WEF and ASCE, Existing Sewer Evaluation and Rehabilitation, McGraw-Hill, 2009.

4. A.K. Keshari, Rainwater Harvesting. Water Digest, 2006.

5. S.W. Smith, Landscape Irrigation: Design and Management, 1st Edition, Wiley, 1996.

6. T.L. Saaty, Decision Making for Leaders, 3rd Revised Edition, RWS Publications, 2012.

7. L.W. Mays, Hydraulic Design Handbook, McGraw-Hill, 1999.

SEMESTER II

HWE502 Water Resources Systems Planning & Management

Introduction: Water resources planning process, multi-objective planning. Evaluation of Water Plans: Basic concepts of engineering economics, welfare economics, economic comparison of alternatives. Water Plan Optimization: Plan formulation, objective functions and constraint, analytical optimization, numerical optimization, linear programming, dynamic programming, simulation, planning under uncertainty. Deterministic River Basin Modelling: Stream flow modelling, estimation of reservoir storage requirements – dead storage, active storage for water supply/ irrigation / power generation, flood storage. Optimal allocation. Conjunctive Use/Groundwater Management Models: LP based conjunctive use modelling, aquifer response models, link - simulation, embedded, matrix response based models, soft modelling. Water Quality Management Models: Basic water quality modelling, objectives of management, control alternatives, optimal plans.

Suggested Books:

1. W.A. Hall and J.A. Dracup, Water Resources Systems Engineering, McGraw Hill Book Company, 1970.
2. D.P. Loucks, Water Resource Systems Planning and Analysis, Prentice Hall, 1981.
3. Maass et al., Design of Water-Resource Systems, Harvard University Press, 1962.
4. S. Vedula and P.P. Mujumdar, Water Resources Systems, Tata McGraw Hill, 2005.

HWE504 Advanced Open Channel Hydraulics

Open Channel Flow: Kinds of open channel flow, channel geometry, types and regimes of flow, Velocity distribution in open channel, wide open channel, specific energy, critical flow and its computation. Energy in non-prismatic channel, mornentum in open channel flow, specific force. Qualification of uniform flow, velocity measurement, Manning's and Chezy's formula, determination of roughness coefficients. Determination of normal depth and velocity, most economical sections, non-erodible channels. Flow in a channel section with composite roughness, flow in close conduit with open channel flow. Varied Flow: Dynamic equations of gradually varied flow, assumptions and characteristics of flow profiles, classification of flow profile, draw down and back water curves profile determination, graphical integration, direct step and standard step method, numerical methods, flow through transitions Varied Flow: Dynamic equation of spatially varied flow. Analysis of spatially varied flow profile, computation of spatially varied flow using numerical integration. Unsteady Flows: St. Venant's equations and their solution using method of characteristics and finite difference schemes; dam break problem, hydraulic flood routing. Channel Transitions: Sub-critical and supercritical.

Suggested Books:

1. V.T. Chow, Open Channel Hydraulics, McGraw Hill, 1959.
2. M.H. Choudhary, Open-Channel Flows, Prentice-Hall, 1994.
3. K.G. Ranga Raju, Flow Through Open Channels, Tata McGraw Hill, 2003.
4. H. Chanson, The Hydraulics of Open Channel Flow: An Introduction, Elsevier, 2004.

HWE5402 Design of Flood Control and River Training Works

Basic causes of flood: Flood prone areas in India and their problems, case history of some important river basins of India. Engineering and administrative methods of flood plain regulation. Economic aspects of flood control schemes, cost benefit analysis. Flood forecasting, flood warning and flood fighting. Morphological study of river behaviour. Theories of river meandering and river regimes. Necessity, principles and methods of river training. Case history of river training works in India and abroad. Design of Levees, Groynes, Cut-offs and Guide bunds etc. River training works for different hydraulic structures.

Suggested Books:

1. R.J. Garde, River Morphology, New International Publishers, 2006.
2. P.Y. Julien, Erosion and Sedimentation, Cambridge University Press, 1998.
3. P.P.H. Jansen, Principals of River Engineering, VSSD Publications, 1994.
4. R.J. Garde and K.G. Ranga Raju "Mechanics of Sediment Transportation and Alluvial Stream Problems" Wiley Eastern Limited, 2006.

HWE5404 Irrigation and Drainage Engineering

Water Resources of India - Irrigation- Need, Advantages and Disadvantages, History of Irrigation development in India- National Water Policy- Inadequacy of Irrigation Management- Criteria for good Irrigation management. Introduction: Water resources planning process, multi-objective planning. Soil physical properties influencing Soil-water Relationship-Forms and occurrence of Soil Water Classification of Soil Water- Soil Water Constants- Energy concept of Soil Water-Forces acting on Soil Water- Soil Water Potential concept- Soil Water retention- Soil Moisture Measurement. Water requirement of crops- Evapotranspiration and Consumptive use- Methods of estimating Evapotranspiration- Effective Rainfall- Irrigation Requirement-Duty of Water- Irrigation Efficiencies Irrigation Scheduling- Irrigation measurement. Canal network and canal design- Surface irrigation methods- Types- Border irrigation, Furrow irrigation and Strip irrigation- Specifications, Hydraulics and Design. Problems of water logging- salinity and alkalinity, land drainage problem- design of surface and sub-surface drainage system, reclamation Water Quality Management Models: Basic water quality modelling,

Suggested Books:

1. W.R. Walker and G.V. Skogerboe, Surface Irrigation Theory and Practice, Prentice Hall,1987.
2. Drainage Principles and Applications, International Institute for Land Reclamation and Improvement, Wageningen, 1973.
3. A.M. Michael, Irrigation: Theory and Practice, Vikas Publishing House, 1978.
4. G.L. Asawa, Irrigation Engineering, New Age International Publishers, 1996.

HWE5406 Hydrometeorology

Atmosphere: General Circulation, Composition and Structure of Atmosphere, Role of Meteorology in Hydrology. Precipitation Process – Adiabatic Process Stability and Instability of Atmosphere, Atmosphere thermodynamics. **Clouds** – Classification, Formation and Characteristics Climate, Preparation of Climatological norms and Climate Classification Weather Charts: Preparation, Analysis and Interpretation. Weather Forecast Monsoon – Monsoon Circulation, Monsoon Troughs, Monsoon Depression and Tropical Cyclones Hydro-meteorological Instrumentation and Observations. Use of Radar and Satellites in Hydrology. Storm Analysis: Storm Selection, Storm Maximization Probable Maximum Precipitation, Meteorological Homogeneity, Storm Transposition Computer applications in the design of hydraulic structures.

Suggested Books:

1. P.S. Eagleson, Dynamic Hydrology, European Geophys Union, 2003.
2. S.L. Dingman, Physical Hydrology, Prentice Hall, 2002.
3. V. Lakshmi, J. Albertson and J. Schaake, Land Surface Hydrology Meteorology and Climate - Observations and Modeling. Amer. Geophys. Union, 2001.
4. C. J. Wiesner, Hydrometeorology, Chapman & Hall, 1970.

HWE5408 Hydro-informatics and Simulations

Introduction, Concept of hydro-informatics scope of internet and web based modelling in water resources engineering. Introduction to multi criterion decision support system – Components for modelling software. Introduction to Simulation, Different simulation techniques – Applications of

simulation techniques in hydraulics. Introduction to Artificial Neural Networks, Networks and its Training-Back propagation algorithm, Conjugate gradient algorithm, Cascade correlation algorithm, Applications of ANN in WRE. Genetic Algorithm (G.A.) Concept, Basic principle of GA, Working principle of GA. Coding, Fitness function, GA. Operations, Reproduction, Cross over Mutation, Applications of GA in Water Resources Engineering.

Suggested Books:

1. P. Kumar, Hydro informatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press, 2005.
2. R. Grayson and G. Blöschl, ed., Spatial Patterns in Catchment Hydrology: Observations and Modelling, Cambridge University Press, 2000.
3. S.K. Tomer, Python in Hydrology, Grean Tea Press, Indian Institute of Science, 2012.

HWE5302 MINOR PROJECT

HWE5304 Applications of GIS and Remote Sensing in Water Resources Engineering

Introduction, Geographical concepts and Terminology, Difference between Image Processing system and GIS, Utility of GIS. Various GIS packages and their salient features, Essentials components of GIS, Data acquisition through scanners and digitizers. Raster and Vector Data: Introduction, Descriptions: Raster and Vector data, Raster Versus Vector, Raster to Vector conversion, Remote Sensing Data in GIS, Topology and Spatial Relationships. Data storage verification and editing Data preprocessing, Georeferencing, Data compression and reduction techniques, Run length encoding, Interpolation of data, Database Construction, GIS and the GPS, Data Output Database structure, Hierarchical data, Network systems, Relational database, Database management, Data manipulation and analysis. Spatial and mathematical operations in GIS, Overlay, Query based, Measurement and statistical modelling, Buffers, Spatial Analysis, Statistical Reporting and Graphing. Programming languauges in GIS, Virtual GIS, Web GIS, Application of GIS to various natural resources mapping and monitoring and engineering problems.

Suggested Books:

1. P.A. Burrough and R.A. Mc Donnel, Principles of Geographic Information System, Oxford University Press, 2000.
2. Chrisman, R. Nicholas, Exploring Geographic Information Systems, John Wiley, 2002 .
3. Demers, N. Michael, Fundamentals of Geographic Information System, 2nd Ed. Wiley, 2008.
4. S.K. Ghosh and A.M. Chandra, Remote Sensing and GIS, Narosa Publishing House, 2008.
5. C.P. Lo and A.K.W. Young, Concepts and Techniques of Geographical Information System, Prentice Hall India, 2002.

HWE5306 Soil Structure Interaction

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems. Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of

continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads. Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space. Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models. Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion.

Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Suggested Books:

1. S K Garg, Soil Mechanics and Foundation Engineering, Khanna Publications, 2003.
2. C Venkataramaiah, Geotechnical Engineering, New Age International Publishers.
3. E. Tsudik, Analysis of Structures on Elastic Foundations, J. Ross Publishing, 2012.
4. J. P. Wolf, Dynamic soil-structure interaction, Prentice Hall int, 1985.

HWE5308 Disaster Mitigation and Management

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data. Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt. Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building. Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime. Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development. Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building. Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Suggested Books:

1. D. K. Chester,EA Bryant,Natural hazards, Cambridge University Press, 1991.
2. P. Blaikie, T. Cannon, I. Davis & B. Wisner, At risk: natural hazards, people's vulnerability and disasters. Routledge, 2003.

3. National Disaster Management Agency Documents, www. http://ndma.gov.in
4. FEMA Documents, http://www.fema.gov
5. A. Coburn and R. Spence Earthquake protection, Wiley, 2002.
6. L.Reiter, Earthquake hazard analysis: issues and insights, Columbia University Press, 1991.
7. D. J. Dowrick, Earthquake risk reduction, Wiley, 2003.
8. K. Aki & P. G. Richards, Quantitative Seismology: Theory and Methods, University Science Books, U.S., 1997.
9. D. Mileti, Disasters by Design:A Reassessment of Natural Hazards in the United States, Joseph Henry Press, 1999.

HWE5202 Groundwater Hydrology

Introduction: Definition of groundwater, role of groundwater in hydrological cycle, groundwater bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity. Wells and Well Hydraulics: Different types of wells, construction of wells, steady and unsteady state solutions for confined, unconfined and leaky aquifers, effect of boundaries, Multiple Well Systems, Partially Penetrating Wells, Well for special Conditions, Characteristics Well Losses, Specific Capacity Surface investigation of Ground water: Geologic methods, Remote sensing, geophysical exploration, Electric resistivity Method, Seismic Refraction Method, Gravity and Magnetic Methods, Water Witching. Concept of Artificial Recharge of Ground water, recharge methods, research on water spreading, Wastewater recharge for reuse, Recharge Mounds. Artificial Recharge on long Island, New York, Include Recharge, artificial Recharge for Energy purposes. Groundwater Flow Modelling: Porous media models, Analog models, Electric Analog Models and Digital computer models.

Suggested Books:

1. D.K. Todd, Groundwater Hydrology, John Wiley, 1959.
2. J. Bear, Hydraulics of Groundwater, McGraw, 1979.
3. H. Bouwer, Groundwater Hydrology, McGraw Hill, 1978.
4. W.C. Walton, Groundwater Resources Evaluation, McGraw Hill, 1970.
5. Freeze and Cherry, Groundwater, Prentice Hall, 1979.

HWE5204 Transients in Pipes

Introduction, Causes of transients; Governing Equations; explanations of equation with real life example, Method of characteristics; Transients in pumping schemes and hydroelectric schemes. Transient bubble flow, Transient control.

Suggested Books:

1. G.Z. Watters, Analysis and control of unsteady flow in pipelines,2nd Ed., Butter Worth Publishers, 1984.
2. Q. Syed, R.M. Edward and M.Z. Guang, Water Works Engineering: Planning, Design and Operation, PHI Learning, 2011.

3. Viessman Jr, J.M. Hammer, E.M Perez and P.A Chadik, Water Supply and Pollution Control, PHI Learning, 2009.

4. M.H. Choudhary, Applied Hydraulic Transients, 2nd Ed., Van Nostrand Reinhold, 1987.

HWE5206 Offshore Geotechnical Engineering

DESIGN OF OFFSHORE PLATFORMS: Introduction, fixed and floating platforms, case studies and general features, elements of hydrodynamics and wave theory, fluid structure interaction, steel concrete and hybrid platforms Consolidation and shear strength characteristics of marine sediments. Design Criteria: Environmental loading, wind, wave and current loads after installation, stability during towing Foundations: Site investigations, piled foundation, foundations for sgravity structures, pile-supported structures. Behaviour under dynamic loading, static and dynamic analysis of platforms and components. Dynamic response in deterministic and indeterministic environment, codes of practice, analysis of fixed platform and semisubmersible related topics.

Suggested Books:

1. S. Gourvenec and D. White, Frontiers in Offshore Geotechnics II, CRC Press, 2005.

2. V. Meyer, Frontiers in Offshore Geotechnics II, CRC Press, .

3. A S Balasubramaniam, Geotechnical Aspects of Coastal and Offshore Structures: Proceedings of the Symposium, Bangkok, CRC Press.

HWE5208 Waste to Energy

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors. Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production. Urban waste to energy conversion - Biomass energy programme in India.

Suggested Books:

1. A.V. Desai, Non Conventional Energy, Wiley Eastern Ltd., 1990.

2. K.C. Khandelwal and S.S. Mahdi, Biogas Technology - A Practical Hand Book - Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

3. D.S. Challal, Food Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd., 1991.

4. C.Y. WereKo-Brobby and E.B. Hagan, Biomass Conversion and Technology, John Wiley & Sons, 1996.

SEMESTER III

HWE651 Research Project

HWE601 Major Project-1

HWE6401 Design of Hydraulic Structures

Project planning of hydraulic structure, site investigation, selection of hydraulic structures (w.r.t foundation), Different types of dam. Design and Construction of Gravity Dams. Design and Construction of Earthen Dams and Rockfill Dams. Design & analysis of weirs and barrages. Design and Analysis of different types of spillway and energy dissipaters.

Suggested Books:

1. P. Novák, A.I.B. Moffat, C. Nalluri, and R. Narayanan, Hydraulic structures, CRC Press, 2006.
2. W.P. Creager, J.D.W. Justin and J. Hinds, , Engineering for dams, Willey, 1929.
3. W.P. Creager, J.D. Justin and J. Hinds, Engineering for Dams: Earth Rock-fill Steel and Timber Dams, John Wiley & Sons, 1945.
4. R.K. Linsley and J.B. Franzini, Water Resources Engineering, McGraw-Hill Publications, New York, 1991.
5. S. Leliavsky, Design textbooks in civil engineering, Chapman and Hall, 1981.
6. B. Singh, Fundamentals of Irrigation Engineering, Nem Chand & Bros,1979 .
7. R.S. Varshney, S.C. Gupta & R.L. Gupta, Theory & Design of Irrigation Structures: Nem Chand & Bros, 2007.
8. S.K. Garg, Irrigation engineering and hydraulic structures, Khanna publishers, 1976.

HWE6403 Environmental Impact Assessment

Objectives of environmental impact assessment, methodology for EIA, Baseline study, scooping, checklist scaled and weighted matrices networks overlays index methods, Prediction and Assessment of impacts on air, water, land, demography and Biological Environment. Impact analysis of Hydro power/ Thermal power project, different case studies, environmental Impact Analysis-Laws and Status in India. Elements of environmental auditing-material and fuel balance. Conversion efficiency of manufacturing processes. Identification of process operation imbalances resulting in resources loss and their impact on environment.

Suggested Books:

1. L.W. Canter, Environmental Impact Assessment, McGraw Hill Pub. Co., 1997.
2. D.P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, 2003.
3. B.B. Hosetti and A. Kumar, , Environmental Impact Assessment & Management, Daya Publishing House, 1998.
4. P. Wathern, Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.

HWE6405 Water Pollution Control and Stream Sanitation

Water quality and stream quality standards Organic self-purification-quantitative definition-re-oxygenation-oxygen balance and stream dissolved oxygen profile-oxygen sag curve-Streeter Phelp's equation-Critical deficit problems. Microbial self-purification-pathogenic microorganisms of sewage origin-indices of contamination-enumeration-per-capita contribution-seasonal variations-death rate survival in the stream environment. Classification of streams-natural self-purification process-disposal of wastewater Rational stream sanitation practices-dual objectives of stream sanitation practices-the science and art of applied stream sanitation-stream survey-types of stream survey-execution of stream surveys. Purification in estuaries-evaluation of self-purification in estuaries-tides and currents distribution of waste loads by tidal translation-sea water intrusion-waste assimilation capacity of estuaries-bacterial contamination-stable wastes. Case studies/simulation studies water quality modelling using qual2E/ WASP.

Suggested Books:

1. V.M. Eulers, and E.W. Steel, Municipal and Rural Sanitation, 6th Ed., McGraw Hill Book Company, 1965.
2. J.E. Park, and K. Park, Text Book of Preventive and Social Medicine, Banarsidas Bhanot, 1972.
3. F.B. Wright, Rural Water Supply and Sanitation, E. Robert Krieger Publishing Company, Huntington, New York, 1977.
4. P. Juuti, S.K. Tapio, and H. Vuorinen, Environmental History of Water: Global Views on Community Water Supply and Sanitation, Iwa Publishing, 2007.

HWE6407 Stability Analysis of Slopes

Introduction: Natural and manmade slopes, types of slope movements & landslides, nature of soil & rock. Progressive failure of slopes; Limit Equlibrium Methods: Infinite and finite height slopes, Planar failure surface; Slip surface of arbitrary shape. Natural slope analysis considering initial stresses; Sewdish method, Bishop's simplified method, other methods, stability chart, Various conditions of analysis, factor of safety, codal provisions. Some special aspects of slope analysis, i.e Earthquakes, Creep, Anisotropy; Probabilistic approach in slope analysis. Centrifuge Model testing. Reinforced slopes, embankment on soft soils.

Suggested Books:

1. H.R. Cedergren, Seepage Drainage and Flow Nets, 3rd Edition, John Wiley & Sons, Inc., New York, 1989.
2. J.M. Duncan and S.G. Wright, Soil Strength and Slope Stability, John Wiley & Sons, Inc., New Jersey, 2005.
3. Gapal, Ranjan and Rao, Basic Mechanics And Foundation Engineering, Khanna publication, 2010.

HWE6301 Water Resource Economics

Principles of engineering economics: discounting techniques, un-certainity, planning horizon. Selection of optimal alternatives. Application of liner, non-linear and dynamic programmings in water resources. Optimal sequencing and scheduling of resources. Planning of water resources projects, cost- benefit analysis for irrigation. Application of liner, non-linear and dynamic programming's water power generation and flood control projects. Engineering and administrative methods of flood plain

regulation. Economic aspects of flood control schemes, cost benefit analysis. Flood forecasting, flood warning and flood fighting.Suggested Books:

1. R.C. Griffin, Water Resource Economics, MIT Press, 2006.
2. E. Kuiper, Water Resources Project Economics, Butterworth Pub. Co, London, 1971.
3. D.G. James, and R.R. Lee, Economics of Water Resources Planning, McGraw Hill Publishing Co, N.York, 1979.
4. L.D. James, and R.R. Lee, Economics of Water Resources Planning, McGraw-Hill, 1971.
5. S. Merrett, Introduction to Economics of Water Resources: An International Perspective, Routledge Publishers, UK, 1997.

HWE6303 An Introduction to Sustainable development

Introduction: Definition of sustainable development, Importance and History of sustainable development Sustainable development systems & PURA, Eco friendly sustainable development, Community driven sustainable development system, Enterprise creation leading to empowerment. Evolution of Sustainable Development, The sustainable development goals, pathways to sustainable development. Challenges of sustainable development, Global Environmental and Energy Issues Sustainable Development Indicators, Environmental assessment, Environmental Management: Trends & policies. Introduction to Economic growth, Brief History of economic development, Human Dev elopement Indicators. Global environmental threats caused by economic development, economics of sustainability, Education for all, Health for all, food for all, Food security Resilient cities, Climate change, saving Biodiversity and protecting eco system services.

Suggested Books:

1. APJ Abdul Kalam & S.P Singh, Target 3 Billion Innovative Solution towards Sustainable Development, Penguin India,2011.
2. H. Sharma, T. Sobti, An introduction to Sustainable Development Goals, 2018.
3. P.P. Rogers, K.F. Jalal, J. Boyd, An introduction to Sustainable Development, Routledge, 2007.
4. J.D. Sachs, The age of sustainable Development, Columbia University Press, 2017.

HWE6305 Ground Improvement Techniques

Introduction: situations where ground improvement becomes necessary. Mechanical modification: dynamic compaction, impact loading, compaction by blasting, vibro-compaction; pre-compression, stone columns; Hydraulic modification: dewatering systems, preloading and vertical drains, electro-kinetic dewatering Chemical modification; modification by admixtures, stabilization using industrial wastes, grouting. Thermal modification: ground freezing and thawing. Soil reinforcement: Reinforced earth, basic mechanism, type of reinforcements, selection of stabilisation/improvement of ground using Geotextiles, Goegrid, geomembranes, geocells, geonets, and soil nails. Application of soil reinforcement: shallow foundations on reinforced earth, design of reinforced earth retaining walls, reinforced earth embankments structures, wall with reinforced backfill, analysis and design of shallow foundations on reinforced earth, road designs with geosynthetics

Suggested Books:

1. M.R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
2. R. Yonekura, Terashi, M. and Shibazaki, M. (Eds.), Grouting and Deep Mixing, A.A. Balkema, 1966.
3. M.P. Moseley, Ground Improvement, Blackie Academic & Professional, 1993.
4. P.P. Xanthakos, L.W.Abramson, and D.A. Bruce, Ground Control and Improvement, John Wiley & Sons, 1994.
5. R.M. Koerner, Designing with Geosynthetics, Prentice Hall Inc, 1998.

HWE6307 Probability and Statistical Methods in Engineering

Preliminary data analysis: Graphical representation of data (stem and leaf plot, box plot, Q-Q Plots), frequency distribution, measure of central tendency-grouped and ungrouped data, measure of dispersion, measure of asymmetry, measure of peakedness, covariance, correlation coefficient. Random events: Sample space and events, Interpretation of probability, Probability axioms, Elementary theorems, conditional probability, Bayes' theorem. Random Variables: Definition of random variables - discrete and continuous; Probability definitions - PMF, PDF, CDF; Moments and expectations. Concept of risk and reliability Probability Distributions: Discrete distributions - binomial distribution, Poisson's distribution; Continuous distributions – uniform distribution exponential distribution, gamma distribution, Weibull, Normal and lognormal distributions. Extreme value distributions, Multivariate distribution-Bivariate Normal distribution, other bivariate distribution, Transformations to Normal distribution. Model Estimation and Testing: Properties of estimators, sampling distributions-Chi square distribution, t-distribution, F distribution, Parameter estimation-Point estimation, confidence interval estimation, Hypothesis testing-Tests of hypotheses on the mean and variance, Goodness-of-fit tests, fitting theoretical distributions to observed frequency distributions and Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test). Curve fitting: method of least squares, simple linear regression, coefficient of correlation and the sample correlation, multiple linear regression. Principal component analysis. Case study of Monte Carlo simulation.

Suggested Books:

1. A. Haldar and S. Mahadevan, Probability reliability and statistical methods in engineering design, John Wiley and Sons,1999.
2. J.R. Benjamin and C.A. Cornell, Probability statistics and decisions for civil engineers, John Wiley,2014.
3. A Papoulis, Probability random variables and stochastic processes, 3rd Edition, McGraw-Hill,2002.
4. N.T.Kottegoda and R.Rosso ,Probability Statistics Reliability for Civil and Environmental Engineer, McGraw-Hill College, 1997.
5. R.A Jonson, Miller and Freund's Probability and Statistics for Engineers, Pearson Education,2011.
6. S.M. Ross, Introduction to Probability and Statistics for Engineering and Scientist, Academic Press, 2009.

HWE6201 Subsurface Investigations

Introduction & broad classification of subsurface methods. **Direct Methods:** Excavation & Pitting, Well Drilling Techniques, Drill Stem Testing, Geological Well Logs. **Indirect Methods:** Geophysical Well Logging, Electrical Well logging methods Normal & Lateral Resistivity, Logs, Self-Potential Logs, Induction & Micro focused logs; electrical logging practices. Evaluation of aquifer parameters Radiation logging (Natural gamma, neutron & gamma gamma logging) - Acoustic Logs Caliper logs & Dip-meter surveys, & their applications in groundwater prospecting.

Suggested Books:

1. R.E. Hunt, Geotechnical Engineering Investigation Manual, Second Edition, Mc Graw Hill, 2005.
2. B.M. Das, Principles of Geotechnical Engineering, Seventh Edition, Cengage Learning Inc, 2010.
3. P. Purushothama Raj, Soil Mechanics & Foundation Engineering, Pearson Education India, 2008.

HWE6203 Introduction to AI Techniques

Expert Systems (ES): Basic concepts of ES, definition and components of ES. Reasoning mechanisms e.g. forward reasoning and backward reasoning, concept of causable variable, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, linear and nonlinear behaviour of variables, statistical concepts and their applications to engineering and sciences; Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feed-forward and feed-back networks, supervised and unsupervised learning methods–standard back-propagation (BP), concept of learning, learning rate and momentum concepts, self-organizing networks, etc., development of ANN models for specific problems and selected case studies. Introduction to Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operators-selection, crossover, and mutation, binary and real-coded GAs, selected case studies involving GA applications to engineering.

Suggested Books:

1. Russell & Norvig, Artificial Intelligence: A Modern Approach, 3rd edition,Pearson, 2009.
2. Qiangfu Zhao and Tatsuo Higuchi, Artificial Intelligence: From fundamentals to intelligent searches, Kyoritsu, 2017.

HWE6205 Geotechnical Practice for Waste Management System and Ground modifications

Introduction to waste containment, Soil system and soil-water pollution interaction, Structural components of clayey soils for landfill liner, Soil organic matter-soil minerals interaction Site investigation at polluted sites (Geophysical techniques, Hydrological investigations etc.). Landfill liner system, Classification of liners and potential problems for clay barrier system, Leachate & gas collection and removal system, Leachate production and clay-leachate compatibility. Soil attenuation by biochemical, physical & chemical processes, Final covering system, Design of top & drainage layers, Monitoring in the saturated and unsaturated zone, Construction quality control and quality assessment, Challenges associated with landfill design & construction in tropical region. Mechanical modification: Introduction, principles of soil densification, properties of compacted soil and compaction control specifications for quality controls. Hydraulic modification: Introduction, objectives, techniques, Dewatering methods, soil and water relationship, Types of aquifer, Design of Dewatering systems, filtration, drainage and seepage, control, preloading and vertical drains, electro kinetic dewatering and stabilization. Ground Modifications: Physical and chemical Modification: Modification by admixtures,

grouting, and thermal modification. Modification by inclusions and confinement: Soil reinforcement, ground anchorage, and rock bolting soil nailing, crib walls, and gabions.

Suggested Books:

1. D.P. Coduto, Geotechnical Engineering, Pearson Education Asia, 2002.
2. M.R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill International Editions, 1990.
3. P.P. Xanthakos, L.W. Abramson and D.A Bruce, Ground Control and Improvement, John Wiley & Sons, 1994.
4. M.H. Choudhary, Applied Hydraulic Transients, 2nd Ed., Van Nostrand Reinhold, 1987.

SEMESTER IV

HWE652 Research Project

HWE602 Major Project II

DEPARTMENT OF CIVIL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Structural Engineering)

Programme Specific Outcomes

Post graduate student will

1. Formulate, analyze and solve societal problems for sustainable development in the field of structural engineering.
2. Lean towards research of new method of design and construction using innovative / smart materials.
3. Create and apply appropriate computational tools, techniques, resources in structural analysis and design software's for analyzing complex structures.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN STRUCTURAL ENGINEERING (STE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	STE501	Structural Dynamics	Core	4	3	0	2	15	25	20	40	-	17
	2	STE503	Computational Methods in Structural Engineering	Core	4	3	0	2	15	25	20	40	-	
Group B	3	STE5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	STE5301/5303/.....	Elective 2	Elective	3	3	0	0	15	25	20	40	-	
	5	STE5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2/1	0	0/2	20/15	0/25	30/20	50/40	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	STE502	Advanced Theory of Structures	Core	4	3	0	2	15	25	20	40	-	17
	2	STE504	Finite Element Method of Structural Analysis	Core	4	3	0	2	15	25	20	40	-	
Group D	3	STE5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	STE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	0	30	50	-	
	5	STE5202/5204/.....	Elective 6	Elective	2	2/1	0	0/ 2	20/ 15	0/ 25	30/ 20	50/ 40	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	STE651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	STE601	Major Project I	Core	3	0	0	6	0	-	40	60	0	
	2	STE6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	STE6301/6303/.....	Elective 8	Elective	3	3 / 2	0	0/ 2	20/ 15	0/ 25	30/ 20	50/ 40	-	
	4	STE6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													12
	1	STE652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	STE602	Major Project II	Core	12						0	100		

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	STE5401	Design of Advanced Reinforced Concrete Structures	Elective	4	3	0	2	15	25	20	40	-
	2	STE5403	Design of Advanced Steel Structures		4	3	0	2	15	25	20	40	-
	3	STE5405	Prestressed Concrete Design		4	3	0	2	15	25	20	40	-
	4	STE5407	Cyclone Risk and Hazard Assessment		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	STE5301	Theory of Plates & Shells	Elective	3	3	0	0	20	0	30	50	-
	2	STE5303	Theory of Elasticity & Plasticity		3	3	0	0	20	0	30	50	-
	3	STE5305	Stability Analysis of Structures		3	3	0	0	20	0	30	50	-
	4	STE5307	Advanced Building Construction and Management		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	STE5201	Seminar	Elective	2	0	0	2	-	0	-	100	-
	2	STE5203	Advanced Concrete Technology		2	2	0	0	20	0	30	50	-
	3	STE5205	Design of Fibre Reinforced Composite Structures		2	1	0	2	15	25	20	40	-
	4	STE5207	Low Cost Housing		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	STE5402	Analysis and Design of Bridges	Elective	4	3	0	2	15	25	20	40	-
	2	STE5404	Design of Tall Buildings		4	3	0	2	15	25	20	40	-
	3	STE5406	Wind Engineering		4	3	0	2	15	25	20	40	-
	4	STE5408	Earthquake Resistant Design of Structures		4	3	0	2	15	25	20	40	-
	5	STE5410	Reliability Analysis of Structures		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	STE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	STE5304	Soil Structure Interaction		3	3	0	0	20	0	30	50	-
	3	STE5306	Design of Masonry Structures		3	3	0	0	20	0	30	50	-
	4	STE5308	Disaster Mitigation and Management		3	3	0	0	20	0	30	50	-
	5	STE5310	Random Vibration		3	3	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	STE5202	Durability of Concrete Structures	Elective	2	1	0	2	15	25	20	40	-
	2	STE5204	Building Services		2	2	0	0	20	0	30	50	-
	3	STE5206	Waste to Energy		2	2	0	0	20	0	30	50	-
	4	STE5208	Blast Resistant Design of Structures		2	2	0	0	20	0	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	STE6401	Design of Hydraulic Structures	Elective	4	3	0	2	15	25	20	40	-
	2	STE6403	Soil Dynamics		4	3	0	2	15	25	20	40	-
	3	STE6405	Seismic Hazard and Risk Assessment		4	3	0	2	15	25	20	40	-
	4	STE6407	Retrofitting of Structures		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	STE6301	Instrumentation and Rehabilitation of Structures	Elective	3	3	0	0	20	0	30	50	-
	2	STE6303	Structural Vibration Control		3	3	0	0	20	0	30	50	-
	3	STE6305	Ground Improvement Techniques		3	3	0	0	20	0	30	50	-
	4	STE6307	Probability & Statistical Methods in Engineering		3	2	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	STE6201	Sustainable Building Technologies	Elective	2	2	0	0	20	0	30	50	-
	2	STE6203	Pre-Fabricated Structures		2	2	0	0	20	0	30	50	-
	3	STE6205	Form Work for Concrete Structures		2	2	0	0	20	0	30	50	-

SEMESTER I

Courses

STE 501 Structural Dynamics

Vibrations and the nature of time dependent phenomena, inertia, dynamic equilibrium and mathematical models of physical systems; Energy storing and dissipation mechanisms. Degrees of freedom; Application of Newton's laws, D'Alembert's principle. Dynamics of Single Degree of Freedom Systems, undamped and damped, free and forced vibrations; Steady-state and transient response, impulse response. Harmonic response and applications to vibration isolation; theory of seismic pickups: Seismometers, accelerometers. Dynamics of Multi-Degree of Freedom Systems, Lagrange's equations; equations of motion for MDOF systems; Algebraic eigenvalue problem and free vibration analysis; Undamped and damped normal modes; Approximate Methods for Vibration Analysis, Rayleigh method, Stodola Method, Holzer Method. Dynamics of Continuous Systems, Hamilton's principle; Axial and transverse vibrations of beams, torsional vibrations of shafts; Normal modes; Free and forced vibration analysis by mode superposition.

Suggested Books:

1. P. Agarwal, M. Shrikhande, Earthquake Resistant Design of structures, Prentice –Hall India, 2006.
2. A. K. Chopra, Dynamics of structures (Vol. 3), New Jersey: Prentice Hall, 1995.
3. S.K. Duggal, Earthquake Resistant Design of Structures, Oxford University Press, 2007.
4. J.W. Tedesco, Ms W.G. Dougal, C.A. Ross, Structural Dynamics Theory and Application, Addison-Wesley, England, 1999.
5. M. Paz , Structural dynamics: theory and computation, Springer Science & Business Media, 2012.

STE 503 Computational Methods in Structural Engineering

Linear Systems and Equations: Exact methods: LU-decomposition, Gauss-elimination methods without and with partial pivoting. Iterative methods: Gauss-Jacobi and Gauss-Seidal methods, Matrix norm, Condition number and Ill-conditioning. Eigen values and Eigen vectors: Largest and Smallest eigen values and eigen vectors by power method. Application to structural engineering problems. Roots of Non-linear Equations: Bisection, Regula Falsi, Secant Newton–Raphson methods, Direct Iterative method with convergence criterion, Newton-Rapson method, Extension of Newton-Raphson and Iterative methods for two variables. Finite Differences and Divided Differences:Operators, Difference table, Propagation of errors, Divided differences with properties. Application to structural engineering problems. Interpolation: Interpolation Formulae: Newton's forward, backward, Stirling's and Bessel's formulae, Newton's divided difference and Lagrange's formulae, Errors in various interpolation formulae. Inverse Interpolation: Successive approximation and Lagrange's method. Numerical Differentiation: Various formulae for first and second derivative with errors. Application to structural engineering problems. Numerical Integration: Newton-Cotes formulae, General quadrature formula for equidistant ordinates, Trapezoidal, Simpson's 1/3 and 3/8 rules with their geometrical interpretations and errors, Romberg integration and Gaussian quadrature formulae. ODEs: Initial Value Problems :Euler's methods; Runge-Kutta methods; Predictor-corrector methods; ODEs: Boundary Value Problems:Shooting method; Finite differences; Over/Under Relaxation (SOR). Application to structural engineering problems. Regression and Curve Fitting: Linear regression; Least squares; Total Least Squares; Interpolation; Newton's Difference Formulae; Cubic Splines. Computer Algorithms: Numerical Solutions for Different Structural Problems, Fuzzy Logic and Neural Network. Computer programming using MATLAB and its application in solving structural engineering problems.

Suggested Books:

1. S.P. Venkateshan and P. Swaminathan, Computational Methods in Engineering, Ane Books Pvt. Ltd, 2017.
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw hill, 2016.
3. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, 1998.
4. M.K. Jain, S.R. Iyengar & R.K. Jain, Numerical Methods for Scientific & Engineering Computation, New Age International Publisher, 2010.

STE5401 Design of Advanced Reinforced Concrete

Review of limit state design and loadings as per applicable codes. Analysis, design and detailing of simple buildings. Analysis, design and detailing of folded plates and cylindrical shells (beam and arch theory). Analysis, design and detailing cylindrical water tanks resting on ground (fixed and hinged boundary conditions at base). Analysis, design and detailing of circular silos including foundations. Analysis, design and detailing of cylindrical chimneys including foundations. Retaining walls: Types of retaining walls, Analysis and design of cantilever type retaining walls, Analysis and design of counterfort and buttress type retaining walls, Analysis and design of Abutments.

Suggested Books:

1. Pillai and Menon, Reinforced Concrete Design, TMH, 2003.
2. S.R. Karve and V.L. Shah, Limit State Theory and Design of reinforced Concrete, VGP, 2014.
3. P. C. Varghese, Advanced Reinforced Concrete Design, PHI, 2015.
4. G. Winter, Design of Concrete Structures, McGraw Hill, 1986.

STE5403 Design of Advanced Steel Structures

Introduction to multi storey buildings, loading, analysis for gravity and lateral loads, computer analysis of rigid frames and advanced structural forms. Introduction to space frames, type of space frames, space trusses, optimality criteria and case studies. Introduction to cold form steel, advantages of cold formed sections, local buckling, beams, axially loaded columns with and without bending and concluding remarks. Introduction to micro-wave towers, types of communication towers, ladders and platforms and codal provisions. Introduction to transmission towers, material properties, ground clearance, tower configurations, factor of safety, loads and their design. Introduction to bridges, steel for bridges, classification of steel bridges, loads and their combinations, analysis and design of plate girder and trussed bridges.

Suggested Books:

1. A.S. Arya and A. Kumar, Design of Steel Structures, Nem Chand and Bros, 2014.
2. Indian Railway Standard, IRS Code of Practice for Design and Construction of Bridges and Structures, Volume - I and II,-Research Design and Standards Organisation, 2004.
3. S.K. Duggal, Design of Steel Structures, 3rd edition, McGraw Hill publication, 2009.
4. IS: 801 Code of Practice for Use of Cold-Formed Light Gauge Steel Structural Members in General Building Construction, Bureau of Indian Standards, 1975.
5. IS: 802 Code of Practice for Use of Structural Steel in Overhead Transmission Line Towers, Bureau of Indian Standards, 1992.

STE 5405 Prestressed Concrete Design

Introduction, Advantages and Types of Pre-Stressing, Pre-Tensioning Systems and Devices, Post-Tensioning Systems and Devices, Concrete and steel properties, Pre-Stressing Steel, Computation of Losses in Pre-stress in pre and post tensioned members. Analysis of Members under Axial Load to get short term and long term un-cracked and cracked response, Calculation of Crack Width and Crack Spacing, Response of Member subjected to Flexure. Numerical method for Calculation of Camber/Deflection ,Composite Construction. Flexural Design of Members strain compatibility and force in tendon approach, Design of Sections for Flexure of One-Way Slabs with bonded and un-bonded tendons, T section / Double T section Floor Beams , Detailing Requirements for Flexure, Control of crack width and deflection. Members subjected to combined axial load and flexure including slender members, Analysis of member subjected to Shear, Modified compression field theory, Torsion, Design for Shear, Design for Torsion, Design for combined flexure , shear and torsion, Transmission of Pre-stress in pre and post tensioned members. Analysis and design of Continuous Beams, Composite Sections, Flat Slabs, Circular Pre-stressing. Design of Pre-Stressed Sleepers, Design of Pre-Stressed Piles

Suggested Books:

1. IS 1343:2012 ,IS 456:2000,IS 3370 Part I to IV , 2009.
2. PCI Design Handbook, ACI 318 Code, CEB-FIP code,BS 8110, 1990.
3. N. Krishna Raju, Pre-Stressed Concrete, Tata McGraw Hill, 2006.
4. T.Y. Lin, Pre-Stressed Concrete Structures, John Wiley and Sons Inc, 2010.

STE5407 Cyclonic Risk and Hazard Assessment

High wind and severe storms: Introduction, types of high wind, hurricanes, typhoons, cyclones Wind Characteristics: Variation of wind velocity with height and roughness, atmospheric circulation-pressure gradient force, Coriolis force, frictional force, geostrophic flow, boundary layer, Static wind effects and building codes with particular reference to IS875(part-I). Tropical Cyclones: General structure of Cyclones, Quantification of Cyclones, Various scales for measuring wind storms, Different types of distribution generally used in wind engineering problems, Probabilistic description of cyclonic wind speed, Exceedance Probabilities, Mean Recurrence Intervals, N-year Speed Estimation from Measured Wind Speeds, wind storm/cyclone hazard in India, wind speed map of India, Frequency of cyclones in India. Cyclonic Microzonation: Cyclone key parameters, Probability distribution of cyclone key parameter, Artificial generation of distribution of velocity at a site using of the cyclone key parameters, Hazard curve, hazard map, Microzonation of Andhra Pradesh and Orrisa. Quantification of damage: Classification of Buildings, Damaging effects of high wind speeds on housing in the coastal region of India Classification of damages according to Indian standard procedure (IS 15499:2004), Impact of Cyclonic Storms and Suggested Mitigation Actions, Different technique used to describe the vulnerability of building. Vulnerability assessment: Concept of vulnerability of houses to cyclonic wind, fragility curve, damage ratio, Direct and component-based approach, Concept of damage probability matrix, Effect of wind directionality on vulnerability of houses. Cyclonic risk assessment, Integrating cyclonic hazard to cyclonic risk, HAZUS.

Suggested Books:

1. E. Simiu & R.H. Scanlan, Wind effects on structures: An Introduction to Wind Engineering, John Wiley, 1986.
2. IS: 15498: Guidelines for Improving the Cyclonic Resistance of Low-Rise Houses and other Buildings/Structures, Bureau of Indian Standard, 2004.
3. N.M. Bhandari, P. Krishna and K. Krishen, Wind storms, damage and guidelines for mitigative measures, Department of Civil Engineering, Indian Institute of Technology, Roorkee, p. 11, Document No. IITK-GSDMA-Wind03-V3.0, 2011.
4. P.K. Goyal, T. K. Datta and V.K. Vijay, Vulnerability of rural houses to cyclonic wind, Int. J. Disaster Resilience in the Built Environment, 2012.
5. "Vulnerability Atlas of India", BMPTC, Ministry of Urban Affairs and Employment, Government of India, 2007.
6. P.K. Goyal and T.K. Datta, Probability Distributions for Cyclone key Parameters and cyclonic wind speed for the east coast of Indian Region, The International Journal of Ocean and Climate Systems, Vol.2 (3), Multi science, 2011.

STE5301 Theory of Plate & Shells

Bending of long rectangular plates in cylindrical surfaces. Differential equations for cylindrical bending of plates. Cylindrical bending equally loaded free supported rectangular plate, fixed rectangular plate, rectangular plate with a flexible fixed ends. Pure bending plate. The slope and curvature of small deflection plate. Relationship between offensive moments and curvature in pure bending plate. Different cases of pure bending. Symmetrical bending of circular plates. Differential equations for symmetric bending transversely loaded circular plates. Uniform load of plates, concentric, the load at the centre. Plate with a round hole in the centre. Plates on elastic foundation, various cases and applications General theory of shells, Differential equations, Energy method.

Suggested Books:

1. S. Timoshenko & S. Woinowsky-Krieger, Theory of plates and shells, (Vol. 2), McGraw-hill, 1959.
2. S.S. Bhavikatti, Theory of plates and shells, New Age International Private Limited, 2017.
3. K. Chandrashekhara, Theory of plates, Universities press, 2001.
4. R. Szilard, Theory and analysis of plates, Prentice-Hall, 1974.

STE 5303 Theory of Elasticity & Plasticity

Introduction to the general theory of elasticity, Assumptions and Applications of linear elasticity. Analysis of Stress: Stress tensors, two-dimensional state of stress at a point, principal stresses in two dimensions, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, equilibrium equations, Mohr's stress circle, equilibrium equations, Numerical examples. Analysis of Strain: Types of strain, strain tensors, strain transformation. Principal strains, strain invariants, octahedral strains. Mohr's Circle for Strain, equations of Compatibility for Strain, Numerical examples. Stress-Strain Relations: Generalized Hooke's law, transformation of compatibility Condition from Strain components to stress components. Strain energy in an elastic body, St. Venant's principle, uniqueness theorem. Two Dimensional Problems in Cartesian Coordinate System: Plane stress and plane strain problems. Stress function,

stress function for plane stress and plane strain cases. Torsion of Prismatic Bars: General solution of the torsion problem, stress function, torsion of circular and elliptic cross sections. Prandtl's membrane analogy, torsion of thin walled and multiple cell closed sections. Numerical examples. Theory of Plasticity: Concept, various materials and their properties, analysis of civil engineering structures as per theory of plasticity.

Suggested Books:

1. S. P. Timoshenko & J.N. Goodier, Theory of Elasticity, McGraw-Hill, 1971.
2. J. Chakrabarty, Theory of plasticity, Butterworth-Heinemann, 2012.
3. A. C. Ugural & S. K. Fenster, Advanced strength and applied elasticity, Pearson education, 2003.

STE5305 Stability Analysis of Structures

Elastic stability: Geometric Non linearity –Basic Concepts. Elastic buckling of bars, Euler's formula, Buckling of continuous beams, buckling of non-prismatic members, effect of shear force on buckling of bars, use of energy method. Analysis of beam-columns with various end conditions, Use of trigonometric series, Buckling of single span portal frames. Torsional buckling: Pure torsion of thin walled open cross section, warping and warping rigidity. Torsional buckling of columns, combined buckling by torsion and flexure, Lateral torsional buckling of beams, lateral buckling of beams in pure bending, lateral torsional buckling of cantilever and S.S. beams, Introduction to buckling of plates.

Suggested Books

1. M. L. Gambhir, Stability analysis and design of structures, Springer Science & Business Media, 2004.
2. A. Chajes, Principles of structural stability theory, Prentice Hall, 1974.
3. G. Gerard, Introduction to structural stability theory, McGraw-Hill, 1961.
4. N. G. R. Iyengar, Elastic Stability of Structural Elements, Macmillan, 2007.

STE5307 Advanced Building Construction and Management

Introduction to building construction, site work and excavation construction methods, Foundation construction methods, structure (concrete) construction methods, structure (steel and wood) construction methods, structure (masonry) construction method Building envelope (roof) systems, building envelope (walls) systems, building envelope design and integration, interior wall and ceiling systems, interior wall and ceiling systems, interior finishes. Speciality construction systems, integrated building design and modelling, construction sequencing Project Scheduling: Construction Scheduling, Work break down structure, activity cost and time estimation in CPM, PERT, RPM (Repetitive Project Modeling) techniques. LOB technique, Mass haul diagrams. Precedence Network Analysis, software in Construction scheduling (MSP, primavera, Construction manager). Construction site management: Site mobilization: demobilization aspects, various Resources management based on funds availability, coordinating, communicating & reporting Techniques, Application of MIS to construction, Training for Construction Managers , Engineers , Supervisors

Suggested Books:

1. C.M.H. Barritt, Advanced Building Construction, Volume 2, Longmans, 1985.
2. H. Fidler, Advanced Building Construction: A Manual for Students, Longmans, Green & Company, 1892.

3. M.P. Calin and C. Chotchal, Project Planning, Scheduling and Control in Construction :An Encyclopedia of terms and Applications, Wiley publication, 1995.

4. K.K. Chitkara, Construction Project Management: Planning Scheduling and Control, Tata McGraw Hill, 2012.

STE5201 SEMINAR

STE5203 Advanced Concrete

Concrete Materials: Cement production, composition, hydration chemistry, Aggregates: Geology of aggregates, Chemical and Mineral admixtures for concrete, High Performance concrete mixture proportioning Concrete Behaviour, Advanced topics in fresh concrete – Rheology, pumping of concrete, Advanced topics in hardened Concrete – Behaviour under various loads, creep & shrinkage, Durability problems of Concrete.

Suggested Books:

1. P. K. Mehta and P. J. M. Monteiro, Concrete: Microstructure, Properties, and Materials, Fourth Edition (Indian Edition), McGraw Hill, 2014.

2. A. M. Neville, Properties of Concrete, Pearson Fifth Edition, 2013.

3. J. Newman & B. S. Choo, Advanced Concrete Technology, Elsevier, 2003.

STE5205 Design of Fibre Reinforced Concrete Structures

Introduction; Types of structural fibers: matrix, fiber and interface; Fiber reinforced concrete (FRC). High-performance concrete; Stress transfer, Bond, Pull-out, Toughening mechanism; Fracture mechanics; Modeling of tensile and flexural behaviors; Behavior under compression; Shear failure theory; Behavior under seismic loading; Composite structural design: Design spirals, Selection Criteria configurations; Laminate design; Mathematical analysis of laminates. Design of single skin panels, Design of composite stiffeners.

Suggested Books:

1. S. B. Singh, Analysis & Design of Fibre reinforced Concrete structures, McGraw-Hill Education, 2015.

2. R.R. Hussain, Fibre reinforced Concrete, VDM Verlag Dr. Müller, 2010.

STE5207 Low Cost Housing

Eco-friendly Planning: Energy Efficient Shelters, Housing Options Today, Site Planning and Use of On-Site Resources, Smaller Houses that Utilize Space and Materials More Efficiently, Working With Nature, Better Window Planning, Balancing Energy and Aesthetic Needs. Eco-friendly Materials: Construction materials –locally available building materials- Soil, Fly ash, Ferrocement, Lime, Fibres, Stone Dust, Red mud, Gypsum,Alternate Wood, Polymer-ADOBE,Cob Rammed Earth, Light Clay, Straw-Bale, Bamboo, Agro-Industrial Waste, Innovative Materials Developed by CBRI, SERC, Structural Properties Of Alternate Building Materials, Earthen Finishes , Earth Plasters, Earth Floors. Cost Effective Construction Techniques: Construction Techniques-Innovative Techniques developed by CBRI, SERC for foundation, superstructure, roofing, pre-fabricated construction techniques, advantage of pre-fabrication areas where pre-fabrication can be introduced, modular contained earth, earth bag construction. Cost Effective Construction Equipments: Equipments-Brick moulding machine, Stablilised soil block making machine and plants for the manufacturing of concrete blocks,

M.C.R. tile making machine, Ferrocement wall panel & Roofing channel making machine, R.C.C. Chaukhat making machine.

Suggested Books:

1. Givoni, Man, Climate, Architecture, Van Nostrand, 1976.
2. J. K. Charles, Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons, 2005.
3. L. Elizabeth and C. Adams, Alternative Construction: Contemporary Natural Building Methods, Softcover, Wiley & Sons, 2005.

SEMESTER II

Courses

STE502 Advanced Theory of Structures

Matrix, Vector, identity, symmetric and skew symmetric, sparse, banded and orthogonal matrices, Addition and multiplication of matrices, inverse of a matrix and matrices for translation, scaling and rotation of an object. Indeterminacy, Static and Kinematic indeterminacies, selection of a method of analysis based on indeterminacies, Principle of Superposition, Actions and Displacements, Flexibility and Stiffness methods of analysis, procedural steps of analysis and numbering of joints for minimum band width. Stiffness matrix of plane frame and continuous beam members, transformation of stiffness matrices from member axes to structure axis system and their assembling. Preparation of load vectors, their transformation from member axes to structure axis system and their assembling. Solution of equations for unknown displacements, determination of support reactions and member end forces. Stiffness matrix of plane truss and grid frame members, transformation of stiffness matrices from member axes to global axis system and their assembling. Preparation of load vectors, their transformation from member axes to global axis system and their assembling. Solution of equations for unknown displacements, determination of support reactions and member forces. Stiffness matrix and rotation transformation matrices for space truss and space frame members. Stiffness matrices for beams curved in plan and elevation, analysis using Sub-structure technique, effect of axial force on flexural stiffness and non-linear analysis of structures

Suggested Books:

1. H.C. Martin, Introduction of Matrix Methods of Structural Analysis, McGraw-Hill, 2005.
2. H. Kardestuncer , Elementary Matrix Analysis of Structures, McGraw-Hill, 1974.
3. W. Weaver Jr. and J.M. Gere, Matrix Analysis of Framed Structures, CBS publishers and distributors, 2004.
4. A. Ghali, A.M. Neville and T.G. Brown, Structural Analysis, Taylor & Francis Ltd, 2003.
5. F.W. Beaufait, W.H. Rowan and P.G. Hoadley, Computer Methods of structural analysis, Prentice Hall, 2000.

STE504 Finite Element Method of Structural Analysis

General concepts of continuum/solid mechanics, State variables, stress, strain-displacement relationships defining different classes of problems, Euler Bernoulli and Timoshenko beam models, Formulation of 3D elasticity, Kirchhoff's plate theory and Mindlin plate theory based plate problems,

Principle of total minimum stationary potential Energy, Stress calculation. Rayleigh Ritz method, Variational formulation of continuous systems, Analysis of continuous systems (discretization approach), Mesh generation techniques, Galerkin and other methods of weighted residual, Generalized and natural coordinate models of displacement field, Convergence criteria, Numerical errors and F.E. model refinements. EBBM based beam problem, Plane stress and plane strain problems using generalized coordinate displacement model, Shape functions for Lagrangian family of rectangular elements, triangular elements, r-s-t coordinate method, Area coordinates, Serendipity elements, Tetrahedron and hexahedron elements, Iso-parametric elements, Elements with curved boundaries, Cartesian mapping relationship from local and natural coordinates, Jacobian, Numerical integration methods. Using natural coordinate displacement model stiffness matrix for truss element, TBM based beam problem, Plane stress/plane strain problems using quadrilateral and triangular elements, Determination of load vector, Plate bending problem with rectangular and triangular elements, Hermitian polynomials and a conforming plate bending element, Initial value and eigen value problems, Axisymmetric elasticity problems, Dissimilar elements, Shear locking defect, Under integration and Suitable integration order and infinite and singularity elements issues, Patch tests, Problems in NISA , ANSYS and other FEM software.

Suggested Books:

1. C.S. Krishnamoorty, Finite Element Analysis, McGraw-Hill, 1994.
2. O.C. Zienkiewicz & R. L. Taylor, The finite element method, (Vol. 3) McGraw-hill, 1977.
3. T. J. Hughes, The finite element method: linear static and dynamic finite element analysis, Courier Corporation, 2012.
4. Y.M. Desai, T.I. Eldho and A.H. Shah, Finite Element Method, Pearson publication, 2011.

STE5402 Analysis and Design of Bridges

Introduction, historical/ magnificent bridges; Site Selection, Planning, and Type of Bridges, Loads and Forces; Code Provisions for Design of Steel and Concrete Bridges; Analysis Methods, Grillage Analogy; Theories of Lateral Load Distribution and Design of Superstructure: Slab Type, Beam-Slab, and Box Type. Applied and Self-Induced Horizontal Forces among Bridge Supports in Straight, Curved, and Skewed Decks; Continuous Type and Balanced Cantilever Type Superstructure Temperature Stresses in Concrete Bridge Deck; Different Types of Foundations: Open, Pile, and Well Foundations; Choice of Foundation for Abutments and Piers; Design of Abutments, Piers, Pile/ Pier Caps. Effect of Differential Settlement of Supports; Bridge Bearings; Expansion Joints for Bridge Decks; Vibration of Bridge Decks; Parapet and Railings for Highway Bridges; Construction Methods; Segmental Construction of Bridges; Inspection and Maintenance of Bridges; Health Monitoring and Evaluation of Existing Bridges; Bridge Failure: Case Studies..

Suggested Books:

1. W. F. Chen & L. Duan, Bridge Engineering Handbook: Construction and Maintenance, CRC press, 2014.
2. J. W. Smith, Theory and design of bridges, Petros P. Xanthakos, Wiley Interscience, 1994.
3. V.K. Raina, Concrete bridge practice – analysis, design and economics, Tata McGraw-Hill Publishing Company Ltd, 2002.
4. J. W. Smith, Theory and design of bridges, Petros P. Xanthakos, Wiley Interscience, 1994.

STE5404 Design of Tall Buildings

Design Criteria and Materials : Development of High Rise Structures – General Planning Considerations – Design philosophies – Materials used for Construction – High Strength Concrete – High Performance Concrete – Self Compacting Concrete – Glass – High Strength Steel. Loading: Gravity Loading – Dead Load – Live Load – Live load reduction technique – Impact Load – Construction Load – Sequential Loading. Lateral Loading – Wind load – Earthquake Load. Combination of Loads. Behaviour of Various Structural Systems: Factors affecting growth, Height and Structural form. High rise behaviour of Various structural systems – Rigid frames, braced frames, Infilled frames, shear walls, coupled shear walls, wallframes, tubular structures, cores, outrigger – braced and hybrid mega systems. Analysis and Design: Modeling for approximate analysis, Accurate analysis and reduction techniques, Analysis of buildings as total structural system considering overall integrity and major subsystem interaction, Analysis for member forces, drift and twist, computerised general three dimensional analysis. Stability of Tall Buildings: Overall buckling analysis of frames, wall-frames, Approximate methods, second order effects of gravity of loading, P-Delta analysis, simultaneous first-order and P-Delta analysis, Translational, Torsional instability, out of plumb effects, stiffness of member in stability, effect of foundation rotation.

Suggested Books:

1. B. S. Smith and A. coull, Tall Building Structures, Analysis and Design, John Wiley and Sons, 1991.
2. B.S. Taranath, Structural Analysis and Design of Tall Buildings, McGraw Hill, 2011.
3. T.Y. Lin & B.D. Stotes, Structural Concepts and systems for Architects and Engineers, John Wiley, 1988.
4. S.B. Lynn, Advances in Tall Buildings, CBS Publishers and Distributors, 1986.

STE5406 Wind Engineering

Introduction: Terminology – Wind Data – Gust factor and its determination - Wind speed variation with height– Shape factor – Aspect ratio – Drag and lift. Effect of Wind on Structures: Static effect – Dynamic effect – Interference effects (concept only) – Rigid structure – Aero elastic structure (concept only). Tail buildings – Low rise buildings – Roof and cladding – Chimneys, towers and bridges. Structural System in Tall Buildings: Different types of structural system, Shear walls of various types; frame – Shear wall interaction; staggered wall – beam system. Electrical transmission towers. Application to Design: Design forces on multi-storey building, towers and roof trusses. Response of high – rise structures to lateral loads and design consideration. Introduction to Wind Tunnel: Types of models (Principles only) – Basic considerations – Examples of tests and their use.

Suggested Books:

1. T.V. Lawson , Wind Effects on Buildings, Vols. I and II, Applied Science and Publishers, 1993.
2. A.G. Devenport, Wind Loads on Structures, Division of Building Research, 1990.
3. B.S. Taranath, Analysis and Design of Tall Buildings, CRC press, 2003.
4. P. Sachs, Wind Forces in Engineering, Pergamon Press, 1992.

STE5408 Earthquake Resistant design of Structures

Conceptual Design: Functional planning, Continuous Load Path, Overall form, Simplicity and Symmetry, Elongated Shapes, Stiffness and Strength, Horizontal and vertical Members, Twisting of Buildings, Ductility, Flexible Buildings, Framing Systems, Effect of Non-Structures, Choice of construction Material. Introduction to Earthquake – Resistant Design: Seismic Design Requirement, Regular and Irregular Configurations, Basic Assumptions, Design Earthquake Loads, Basic Load Combinations, Permissible Stresses, Seismic Method of Analysis, Factors in seismic Analysis, Equivalent Lateral Force Method, Dynamic Analysis, Response Spectrum Method, Time History Method, Torsion, Soft and Weak Storey in Construction, Overturning Moments, Other structural requirements, Earthquake Resistant Design Methods, Response Control. Concept of Ductile Detailing, Introduction to Performance Based Design Step-by-Step Procedure for Seismic analysis of a four storied RC Building as per IS 1893 (Part I): 2002: Introduction, Analysis by Equivalent Static Lateral Force Method, Response Spectrum Method, Time History Method. Design and detailing of RC framed building elements (beam, column, shear wall, diaphragm and beam-column joint) as per IS 13920. Introduction to nonlinear analyses methods, Analysis of a building using nonlinear static procedure, Introduction to capacity design concepts and displacement based design methods.

Suggested Books:

1. P. Agarwal and M. Shrikhande, Earthquake resistant design of structures, Prentice-Hall of India, 2006.
2. T. Paulay and M.J.N. Priestley, Seismic design of reinforced concrete and masonry buildings, John Wiley & Sons, 1991.
3. D. J. Dowrick, Earthquake resistant design - A manual for engineers and architects, John Wiley & Sons, 1977.
4. S.K. Duggal, Earthquake Resistant Design of Structures, Oxford University Press, 2013.
5. P. FEMA, Commentary for the Seismic Rehabilitation of Buildings.FEMA-356, Federal Emergency Management Agency, 2000.
6. A.K. Chopra, Dynamics of structures: theory and applications to earthquake engineering, Prentice hall, 2012.

STE5410 Reliability Analysis of Structures

Introduction to structural safety reliability: Basic statistics: -Introduction; data reduction; histograms; measures of asymmetry; sample correlation. Probability theory: Introduction, random events, random variables, functions of random variables, moments and expectation, common probability distributions, Extremal distribution. Resistance distribution and parameters: Introduction; statistics of properties of concrete and steel, statistics of strength of bricks and mortar, dimensional variations; characterization of variables of compressive strength of concrete in structures and yield strength of steel; allowable stresses based on specified reliability. Probabilistic analysis of loads: Introduction; load as a stochastic process, dead load, live loads, Wind load-introduction; wind speed, return period, estimation of lifetime design wind speed, probability model for wind load. Basic structural reliability: Introduction, computation of structural reliability. Reliability method: Introduction, basic variables and failure surface, first order second moment methods (FOSM). Monte Carlo study of Structural Safety: Concept of monte carlo simulation and applications, case studies using MATLAB System reliability: Series, parallel and mixed system, Modelling of structural system.

Suggested Books:

1. A. Haldar and S. Mahadevan, Probability, reliability and statistical methods in engineering design, John Wiley and Sons, 2000.
2. J.R. Benjamin and C.A. Cornell, Probability, statistics and decisions for civil engineers, John Wiley, 1970.
3. A.H.S. Ang & W.H. Tang, Probability concepts in engineering planning and design, Volume II Decision, Risk & reliability, John Wiley, 1984.
4. A. Papoulis, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, 1991.

STE5302 Minor Project

STE5304 Soil Structure Interaction

General soil-structure interaction problems: Contact pressures and soil-structure interaction for shallow foundations. Concept of sub-grade modulus, effects/parameters influencing subgrade modulus. Analysis of foundations of finite rigidity, Beams on elastic foundation concept, introduction to the solution of beam problems. Analytical Methods of Analysis of Finite Beams on Wrinkler Foundation: Introduction, analysis of finite and infinite beam on wrinkle foundation, method of super position, method of initial parameters and its application to analysis of regular beams, analysis of continuous beams and frames on wrinkle foundation, analysis of frames on wrinkle foundation, analysis of rigid piles with horizontal and vertical loads. Analysis of Beams on Elastic Half Space: Introduction, analysis of Rigid Beams, short beam analysis, long beam Analysis, Analysis of Frame on Elastic Half Space. Dynamic Soil Structure Interaction: Direct and Sub-structure method of Analysis, Equation of Motion for flexible and rigid base, kinematic interaction, inertial interaction and effect of embedment, Temporal and special variation of external loads including seismic loads, continuous models, discrete models and finite element models. Wave Propagation for SSI: Waves in Semi-Infinite Medium, one two and three dimensional wave propagation, dynamic stiffness matrix for out of plane and in plane motion. Free Field Response of Site: Control point and control motion for seismic analysis, dispersion and attenuation of waves, half space, single layer on half space, modelling of boundaries, elementary, local, consistent and transmitting boundaries. Engineering Application of Soil-Structure Interaction: Low rise residential building, multi-storey building, bridges and dams, soil-pile structure interaction.

Suggested Books:

1. E. Tsudik, Analysis of Structures on Elastic Foundations, J. Ross Publishing, 2012.
2. J. P. Wolf, Dynamic soil-structure interaction, Prentice Hall int., 1985.
3. J. P. Wolf & C. Song, Finite-element modelling of unbounded media, Chichester: Wiley, 1996.
4. S.L. Kramer, Geotechnical earthquake engineering (Vol. 80)- Upper Saddle River, NJ: Prentice Hall, 1996.
5. "Structure Soil Interaction" - State of Art Report, Institution of structural Engineers, 1978.

STE5306 Design of Masonry Structures

Behaviour of Masonry Structures During Past Earthquakes: Common modes of failure, effect of unit shapes and mortar type, effect of roof and floor systems; Common deficiencies. Material Properties:

Masonry units- stones, brick and concrete blocks, hollow and solid units; Manufacturing process; Mortar, grout and reinforcement; Various tests and standards. Masonry Under Compression: Prism strength, Failure mechanism, types of construction and bonds; Eccentric loading; Slenderness – effective length and effective height, effect of openings; Code provisions. Masonry Under Lateral Loads: In-plane and out-of-plane loads, bending parallel and perpendicular to bed joints; Shear and flexure behavior of piers; Test and standards; Analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms; Arching action; Combined axial and bending actions. Earthquake Resistant Measures: Analysis for earthquake forces, role of floor and roof diaphragm; Concept and design of bands, bandages, splints and ties; Reinforced masonry; Vertical reinforcement at corners and jambs; Measures in random-rubble masonry; Confined masonry; Code provisions. Masonry Infills: Effect of masonry infills on seismic behaviour of framed buildings; Failure modes; Simulation of infills – FEM and equivalent strut; Safety of infills in in-plane action – shear, compression and buckling; Out-of plane action, arching; Code provisions. Retrofitting of Masonry Building: Techniques of repair and retrofitting of masonry buildings; IS: 13935-1993 provision for retrofitting. Advance Concepts: Strength and ductility; Nonlinear pushover analysis; Performance based design; Vulnerability and fragility analysis.

Suggested Books:

1. P. Thomas & M.J. Priestley, Seismic design of reinforced concrete and masonry Buildings, John Wiley & Sons, 1992.
2. R.G. Drysdale, A.A. Hamid & L.R. Baker, Masonry structures: behavior and design, Prentice Hall, 1994.
3. D. Anderson & S. Brzev, Seismic design guide for masonry buildings, Canadian Concrete Masonry Producers Association, 2009.

STE5308 Disaster Mitigation & Management

Introduction to various hazard, vulnerability and risk, hazard estimation, hazard mapping, effect of site conditions on structures, event monitoring, processing and integration of data. Damages: Grade of damages, direct and indirect damages, damage to structures, lessons learnt Management and mitigation of earthquake: earthquake risk and vulnerability in India, traditional housing construction in rural and urban areas, critical areas of concern in earthquake management, past and present initiative in India, disaster management plan, approaches to seismic risk mitigation, seismic strengthening and retrofitting methods, awareness and preparedness, capacity building Management and mitigation of tsunamis: Tsunami Risk Assessment and Vulnerability Analysis, Coastal Zone Management, Tsunami Preparedness, Structural Mitigation Measures, Regulation and Enforcement of Techno-Legal Regime Management and mitigation of cyclones: Understanding cyclone and wind hazard in India, vulnerability and risk assessment, early warning systems, structural mitigation measures, management of coastal zones, disaster risk management and capacity development Management and mitigation of flood (including urban flooding): The Flood Hazard, Flash Floods, urban flooding, structural measures for flood management, design and management of urban drainage system, urban flood disaster risk management, early warning system and communication, capacity development Management and mitigation of landslide: Introduction to landslide hazard, Landslide Vulnerability and Risk in India, Hazard Zonation Mapping, Geological and Geotechnical Investigations, Landslide Risk Treatment, Landslide Monitoring and Forecasting, Capacity building Disaster Management Act : Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work; Model Town and country planning legislation land use zoning regulation, development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy.

Suggested Books:

1. P. Blaikie, T. Cannon, I. Davis & B. Wisner, At risk: natural hazards, people's vulnerability and disasters, Routledge, 2014.
2. D. Mileti, Disasters by Design: A Reassessment of Natural Hazards in the United States, Joseph Henry Press, 1999.
3. L. Reiter, Earthquake hazard analysis: issues and insights, Columbia University Press, 1991.
4. K. Aki & P. G. Richards, Quantitative Seismology: Theory and Methods, Volume I: WH Freeman & Co, 1980.
5. National Disaster Management Agency Documents, www. http://ndma.gov.in.

STE5310 Random Vibrations

Basic Theory: Meaning and axiom of probability, events, random variables, discrete and continuous distribution, some examples; Functions of random variables, expectations, characteristic functions; Orthogonality principles, sequence of random variables. Stochastic Processes: Counting process, random walk, Markov chain, Gaussian process, filtered point process, Markov process and non-stationary Gaussian process; Stochastic continuity and differentiation, integral, time average, ergodicity; Correlation and power spectrum; Threshold crossing, peak, envelope distribution and first passage problem. Response of Linear Systems to Random Vibrations: Linear response of single and multiple-degree of freedom systems subjected to random inputs; Linear response of continuous systems. Response of Non linear Systems to Random Vibrations: Response of nonlinear systems to random inputs; Equivalent linearization and Gaussian closure technique.

Suggested Books:

1. N. C. Nigam & H. Saunders, Introduction to Random Vibration, 1986.
2. Y. K. Lin & G. Q. Cai, Probabilistic structural dynamics: advanced theory and applications, McGraw-Hill Professional Publishing, 2004.
3. P.H. Wirsching, T.L. Paez & K. Ortiz, Random vibrations: theory and practice, Courier Corporation, 2006.
4. Cho W.S. To, Nonlinear random vibration: Analytical techniques and applications, CRC Press, 2011.

STE5202 Durability of Concrete Structures

Concrete and the environment: interaction; Overview of concrete deterioration: alkali-aggregate reaction, corrosion, carbonation. Permeability of concrete and its measurement: penetration of carbon dioxide and chlorides into concrete. Corrosion of steel in concrete - electrochemistry of corrosion, micro and macro cell corrosion, corrosion cells and currents, role of concrete, prevention of corrosion; Corrosion induced longitudinal cracks: nature and properties of corrosion products; Alkali aggregate reaction: reactive minerals, mechanism of deterioration, identification and tests; Codal provisions for durability; Non-destructive testing; repair/rehabilitation of structures.

Suggested Books:

1. K. Li, Durability Design of Concrete Structures: Phenomena, Modelling and Practice, Wiley publication, 2016.
2. G.C. Mays, Durability of Concrete Structures: Investigation, repair, protection, Taylor &Francis, 1991.

3. L.M. Poukhonto, Durability of Concrete Structures and Constructions: Silos, Bunkers, Reservoirs, Water Towers, Retaining Walls, CRC Press, 2003.

4. L. Chris, Durability of Concrete and Cement Composites, Woodhead Publishing, 2007.

STE5204 Building Services

Water requirements for different types of buildings, simple method of removal of impurities, water saving practices and their potential Service connection from mains, sump and storage tank, types and sizes of pipes, special installation in multistoried buildings. Material, types of fixtures and fitting for a contemporary bathroom– taps – quarter turn, half turn, ceramic, foam flow etc, hot water mixer, hand shower Rainwater harvesting to include roof top harvesting, type of spouts, sizes of rainwater pipes and typical detail of a water harvesting pit. Principles of drainage, surface drainage, shape and sizes of drains and sewers, storm water over flow chambers, methods of laying and construction of sewers Traps– shapes, sizes, types, materials and function, Inspection chambers -sizes and construction, Ventilation of House drainage: Anti siphonage pipe, system of plumbing - single stack , one pipe system, one pipe partially ventilating system and two pipe system, grey water recycling and dual plumbing. Types of fixtures and materials: sinks, shower tray, shower temple, bath tub, Jacuzzi, water closets, flushing cisterns, urinals, sinks , wash basins, bidet, etc. Design of Septic tank, Oxidation pond, Dispersion trench and soak pits. Arrangements of fixtures in a bathroom Treatment system- Root zone treatment system, Decentralized Wastewater Treatment Systems (DEWATS), Soil Bio technology, packaged Bio-Reactor System.

Approaches for solid waste management, Solid wastes collection and removal from buildings. On-site processing and disposal methods, guidelines for municipal solid waste management, e-waste management. Disposal of Wastes: Sanitary land filling, Composting, Vermi-compost, Incineration, Pyrolysis Classification of buildings based on occupancy, causes of fire and spread of fire, Fire fighting, protection and fire resistance, Fire fighting equipment and different methods of fighting fire. Combustibility of materials, Structural elements and fire resistance, Fire escape routes and elements – planning and design. Wet risers, dry risers, sprinklers, heat detector, smoke detectors, fire dampers, fire doors, etc. Application of above studies in current design problems and preparing design layout and details - Plumbing layout of residential and public buildings, Fire fighting layout, Reflected ceiling plan of smoke detectors / sprinklers, etc. Electrical services, illumination and lighting design, Heat ventilation and air conditioning

Suggested Books:

1. S.C. Rangwala, Water supply and sanitary engineering, Charotar publishing house, 2016.

2. C. Shah, Water supply and sanitary engineering, Galgotia publishers, 1998.

3. Technical teachers Training Institute (Madras), Environmental Engineering- Tata McGraw Hill publishing Company Limited, 1983.

4. A. Kamala & D.L.K. Rao, Environmental Engineering, Tata McGraw-Hill publishing company Limited, 1993.

STE5206 Waste to Energy

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications. Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction

and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation. Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors. Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrclysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Suggested Books:

1. A.V. Desai, Non Conventional Energy, Wiley Eastern Ltd, 1990.
2. K. C. Khandelwal and S. S. Mahdi, Biogas Technology - A Practical Hand Book, (Vol. I & II) - Tata McGraw Hill Publishing Co. Ltd., 1983.
3. D. S. Challal, Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd, 1991.
4. C.Y. WereKo-Brobby and E. B. Hagan, Biomass Conversicn and Technology, John Wiley & Sons, 1996.

STE5208 Blast Resistant Design of Structures

Blast Engineering: Explosion Phenomena, Shock Front, Fragmentation,Waves, Ground Shock, and Interaction with Structures. Structural Analysis for Impulsive Loading; Pressure-Impulse (PI) Diagrams; Material Behaviour under High Strain-Rate of Loadings. Blast Resistant Design of Structures; Performance-Based Blast Design; Progressive Collapse; Anti-Terrorism Planning and Design of Facilities. Blast Retrofitting; Indian/ International Standards and Codes of Practice. Numerical Analysis Tools for Blast Analysis using Finite Element (FE) Software and Hydrocodes.

Suggested Books:

1. D.O. Dusenberry, Handbook for blast-resistant design of buildings, John Wiley & Sons, 2010.
2. T. Ngo, P. Mendis, A. Gupta & J. Ramsay, Blast Loading and Blast Effects on Structures, EJSE, 2007.
3. R. W. Clough & J. Penzien, Dynamics of structures, (vol. 2), McGraw-Hill Education, 1993.
4. J.W. Tedesco, W.G. Dougal & C.A. Ross, Structural Dynamics Theory and Application, Addison-Wesley, 1999.
5. A. K. Chopra, Dynamics of structures, (Vol. 3), New Jersey: Prentice Hall, 1995.

SEMESTER III

Courses

STE 651 Research Project

STE 601 Major Project I

STE 6401 Design of Hydraulic Structures

Project planning of hydraulic structure, site investigation, selection of hydraulic structures (w.r.t foundation), Different types of dam. Design and Construction of Gravity Dams. Design and Construction of Earthen Dams and Rockfill Dams Design & analysis of weirs and barrages. Design and Analysis of different types of spillway and energy dissipaters.

Suggested Books:

1. P. Novák, A. I. B. Moffat, C. Nalluri & R. Narayanan, Hydraulic structures, CRC Press, 2007.
2. W. P. Creager, J. D. Justin & J. Hinds, Engineering for Dams: Earth, Rock-fill, Steel and Timber Dams, John Wiley & Sons, 1961.
3. S. K. Garg, Irrigation engineering and hydraulic structures, Khanna publishers, 1987.
4. B.Singh, Fundamentals of Irrigation Engineering, Nem Chand & Bros, 1979.

STE 6403 Soil Dynamics

Introduction: Background and lessons learnt from damages in past earthquakes. Wave Propagation: Waves in semi-infinite media – one, two and three dimensional wave propagation; Attenuation of stress waves – material and radiation damping; Dispersion, waves in a layered medium. Dynamic Soil Properties: Stress & strain conditions, concept of stress path; Measurement of seismic response of soil at low and high strain, using laboratory tests; Cyclic triaxial, cyclic direct simple shear, resonant column, shaking table, centrifuge and using field tests - standard penetration test, plate load test, block vibration test, SASW/MASW tests, cross bore hole; Evaluation of damping and elastic coefficients; Stress-strain behavior of cyclically loaded soils; Effect of strain level on the dynamic soil properties; Equivalent linear and cyclic nonlinear models; Static and dynamic characteristics of soils. Ground Response Analysis: Introduction, one, two and three dimensional analyses; Equivalent and nonlinear finite element approaches; Introduction to soil-structure interaction. Liquefaction: Introduction, pore pressure, liquefaction related phenomena –flow liquefaction and cyclic mobility, factors affecting liquefaction, liquefaction of cohesionless soils and sensitive clays, liquefaction susceptibility; State Criteria –CVR line, SSL, FLS; Evaluation of liquefaction potential: characterization of earthquake loading and liquefaction resistance, cyclic stress ratio, Seed and Idriss method; Effects of liquefaction. Earth Pressure: Active and passive earth pressures; Terzaghi's passive wedge theory, numerical methods, earth pressure measurements.; Seismic design of retaining walls: types, modes of failures, static pressure, seismic response (including M-O Method), seismic displacement, design considerations. Ground Improvement Techniques: Densification, reinforcement, and grouting and mixing, drainage; Reinforced earth: application of reinforced earth under static and dynamic loads, determination of properties of reinforcements, composite materials, reinforced earth drains and other applications.

Suggested Book:

1. S. L. Krammer, Geotechnical Earthquake Engineering, Pearson Education, 1996.
2. S. Prakash, Soil Dynamics, McGraw Hill Book Company, 1981.
3. N.S.V. Kameswara Rao, Dynamics soil tests and applications, Wheeler Publishing Co. Ltd., 2000.
4. G. Ranjan and A.S.R. Rao, Basic and Applied Soil Mechanics, New Age Int. Ltd, 2007.

STE 6405 Seismic Hazard and Risk Assessment

Concepts and Components of Seismic Risk: Hazard, vulnerability, exposure and risk; Estimation of risk from components. Post Earthquake Damage Studies: Earthquake damage surveys, questionnaires and data to be collected, handling and processing of data, classification of damage, estimation of fragility from damage data. Risk Communication: Role of planners, architects, engineers, banks and insurers; Rating of damage assessment, disaster impact analysis. Modelling and Analysis of Structures: Introduction to matrix and finite element procedures, modelling of buildings. Seismic Vulnerability of Buildings and Lifelines: Empirical, analytical, experimental and hybrid approaches, building typology, intensity scales, use of intensity scales for estimating seismic vulnerability, capacity spectrum method, HAZUS methodology, displacement based approach. Assessment of Exposure: Building stock inventory, sources of available information, census data. Behaviour under seismic loading; Composite structural design: Design spirals, Selection Criteria, configurations; Laminate design; Mathematical analysis of laminates. Risk Estimation: Convolution of hazard, vulnerability and exposure to quantify risk, loss ratios,indoor and outdoor casualty rates; Case studies of different projects- RADIUS, HAZUS, PAGER, GEM, EU-RISK.

Suggested Book:

1. S.L. Krammer, Geotechnical Earthquake Engineering, Pearson Education, 1996.
2. "HAZUS-MH, MR1 & MR2 Technical Manual" - FEMA, Federal Emergency Management Agency, Washington, 2006.
3. R. K. McGuire, Seismic hazard and risk analysis, Earthquake engineering research institute, 2004.
4. S. Tesfamariam & K. Goda, Handbook of seismic risk analysis and management of civil infrastructure systems, Elsevier, 2013.

STE 6407 Retrofitting of Structures

Introduction: Terminology; Basic principles of seismic evaluation and retrofitting. Qualitative Methods of Seismic Evaluation: Rapid visual screening procedure (RVSP) and simplified evaluation of buildings; Visual inspection method and non-destructive testing (NDT) method. Quantitative Methods of Seismic Evaluation: Performance based method using nonlinear static push-over analysis (NSP) and non linear dynamic method of analysis (NDP); Estimation of seismic capacity (strength and ductility). Local and Global Methods of Seismic Retrofitting of RC Buildings: System completion; Strengthening of existing components; RC, Steel and FRP Jacketing; Addition of new components – frames, shear walls and braced frames; Introduction to supplemental energy dissipation and base isolation. Re-evaluation of Buildings with Retrofitting Elements: Linear and Non-linear modelling; Modelling of soil and foundations. Seismic Repair and Retrofitting of Earthquake Damaged RC Buildings: Schemes of temporary shuttering damages; Methods of repair and retrofitting. Seismic Evaluation and Retrofitting of RC Bridges: Seismic evaluation and retrofitting techniques for reinforced concrete bridges – columns/piers, cap beams, cap beam-column joint, footing.

Suggested Books :

1. "Seismic Evaluation and retrofit of concrete building" – Vol. I & II"- Applied Technology Council, California, ATC 40, 1996.
2. "Rapid Visual Screening of Buildings for Potential Seismic Hazards", Federal Emergency Management Agency, Building Seismic Safety Council, Washington, D.C., FEMA 154/155, 2002.

3. M.N. Priestley, F. Seible & G.M. Calvi, Seismic design and retrofit of bridges, John Wiley & Sons, 1996.

4. FEMA-356, "Commentary for the Seismic Rehabilitation of Buildings" Federal Emergency Management Agency, 2000.

5. FEMA, P-695 . "Quantification of Building Seismic Performance Factors"- Federal Emergency Management Agency, 2009.

6. FEMA-440, A., "Improvement of nonlinear static seismic analysis procedures"- . FEMA-440,Redwood City, 2005.

STE 6301 Instrumentation and Rehabilitation of Structures

Study of various transducers, Principle of their working, displacement, velocity, acceleration etc, strain gauge & piezoelectric type of transducers. strain measurements, strain gauges (static and dynamic), calculation of stresses and loads from measurements of strains and deflections. Non-destructive testing of concrete, steel structures, Various NDT tests, codal provisions, Proof Load testing. Corrosion of steel and concrete: Theory and prevention. Cracks in buildings: causes and remedial measures. Assessment and evaluation for structural stability of existing structures. Special concrete constructions: fibre reinforced concrete; fibre wrapping, Special concrete like lightweight concrete, ferro cement, fly ash concrete, High performance concrete, concrete admixtures. Techniques for Rehabilitation of RC, Steel and Masonry structures

Suggested Books :

1. S. Singh, Experimental Stress Analysis, Khanna publishers, 1982.

2. IS: 13935; "Repair and Seismic Strengthening of Buildings- Guidelines"- Bureau of Indian Standard; New Delhi, 1993.

3. SP: 25, "Causes and Prevention of Cracks in Buildings"- Bureau of Indian Standard, New Delhi, 1984.

4. J.P. Boomfield, Corrosion of Steel in Concrete, E& FN SPON, 1997.

5. H.E. Soisson, Instrumentation in industry, John Wiley & Sons, Inc, 1975.

STE 6303 Structural Vibration Control

Structural Control: Historical development of structural control and base isolation, active control, passive control, hybrid control, semi active control; Application to new and existing buildings. Theory of Vibration Isolation: Principle of base isolation; Theory of vibration isolation; Components of base isolation; Advantages and limitations; General Design Criteria; Linear and Nonlinear procedures of isolation design; Application of theory to multiple degree of freedom system. Isolation Devices: Laminated rubber bearing, lead rubber bearing, high damping rubber bearing, PTFE sliding bearing, friction pendulum system and sleeved pile system; Modelling of isolation bearings; Design process for multilayered elastomeric bearings and buckling behaviour of elastomeric bearings; Isolation system testing. Energy Dissipation Devices: General requirements; Implementation of energy dissipation devices; Metallic yield dampers, friction dampers, viscoelastic dampers, tuned mass dampers, tuned liquid dampers; Shape memory alloy dampers; Modelling, linear and nonlinear procedures; Detailed system requirements; Application to multistorey buildings; Testing of energy dissipation devices.

Suggested Books :

1. T. K. Datta, Seismic analysis of structure, John Wiley & Sons, 2010.
2. T. T. Soong & M.C. Costantinou, Passive and active structural vibration control in civil engineering, Springer, 2014.
3. R. Skinner, W.H. Robinson, G.H. Mc Verry, An Introduction to Seismic Isolation, John Wiley and Sons, 1993.
4. C. H. Dowding, Blast vibration monitoring and control, Englewood Cliffs: Prentice-Hall, 1985.

STE 6305 Ground Improvement Technique

Introduction: importance and history of ground improvement. Mechanical Modifications: properties of compacted soil, compaction control tests, field compaction, applications. Precompression: technique, procedure, and applications. Sand Drains: method, procedure and applications. Prefabricated vertical drains: method of installation and design. Soil Stabilization: shallow stabilization with additives like lime, fly ash, cement and other materials. Chemical modifications and Grouting. Hydraulic modification: dewatering systems, filtration, drainage and seepage control with geosynthetic. Vibroflotation technique, stone columns, sand compaction piles, dynamic compaction technique, ground freezing, and electro-osmosis. Ground modification by soil reinforcement: reinforcement techniques, use of flexible geosynthetic reinforcement in bearing capacity improvement, slope stability, erosion control, retaining walls and pavements. Difficult soils: collapsible soils, physical parameters and identification, collapse settlement, improvement techniques; expansive soils, general nature, swell test and swelling pressure tests, classification, improvement of expansive soils.

Suggested Books :

1. B. M. Das, Principles of Foundation Engineering, Cengage Learning, 2011.
2. R. M. Koerner, Designing with Geosynthetics, Vol. 1 & 2. Xlibris Corporation, 2012.
3. M.P. Moseley & K. Kirsch, Ground Improvement, Spon Press, 2004.

STE 6307 Probability & Statistical Methods in Engineering

Preliminary data analysis: Graphical representation of data (stem and leaf plot, box plot, Q-Q Plots), frequency distribution, measure of central tendency-grouped and ungrouped data, measure of dispersion, measure of asymmetry, measure of peakedness, covariance, correlation coefficient. Random events: Sample space and events, Interpretation of probability, Probability axioms, Elementary theorems, conditional probability, Bayes' theorem. Random Variables: Definition of random variables - discrete and continuous; Probability definitions - PMF, PDF, CDF; Moments and expectations. Concept of risk and reliability. Probability Distributions: Discrete distributions - binomial distribution, Poisson's distribution; Continuous distributions – uniform distribution exponential distribution, gamma distribution, Weibull, Normal and lognormal distributions. Extreme value distributions, Multivariate distribution-Bivariate Normal distribution, other bivariate distribution, Transformations to Normal distribution. Model Estimation and Testing: Properties of estimators, sampling distributions-Chi square distribution, t-distribution, F distribution, Parameter estimation-Point estimation, confidence interval estimation, Hypothesis testing-Tests of hypotheses on the mean and variance, Goodness-of-fit tests, fitting theoretical distributions to observed frequency distributions and Tests of goodness-of-fit (chi-square test, Kolmogorov-Smirnov test). Curve fitting: method of least squares, simple linear regression, coefficient of correlation and the sample correlation, multiple linear regression. Principal component analysis. Case study of Monte Carlo simulation.

Suggested Books :

1. A. Haldar and S. Mahadevan, Probability, reliability and statistical methods in engineering design, John Wiley and Sons, 2000.
2. J. R. Benjamin and C.A. Cornell, Probability, statistics and decisions for civil engineers, John Wiley, 1970.
3. A. Papoulis, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, 1991.
4. S.M. Ross, Introduction to Probability and Statistics for Engineering and Scientist, Academic Press, 2004.

STE 6201 Sustainable Building Technologies

Technology, Sustainability & Development: Definitions, Dimensions, Interpretations, Concepts and Principles. Economic Development, Energy use and Carbon emissions: Historical trends in energy use and carbon emissions, environmental consequences of fossil energy use, energy conservation, energy efficiency and renewable energy-based development. Energy and Buildings: Concept of energy, production of building materials, energy in various building materials energy in buildings due to building technologies, operational energy in buildings. Alternatives to River Sand in Mortars: Manufacture sand for mortars, cement-soil-sand mortars, iron ore tailing as replacement for sand. More alternatives to river sand in mortars: Filter sand, stabilized mud mortar, water retentivity, demolished brick masonry wastes, pond ash, granulated blast furnace slag. Sustainability and Resources for Buildings: Material resources and buildings, material composition of buildings, human resource and sustainability. Green buildings: Concept of green building, energy and carbon emission reduction, sustainable resource use and affordability, the green rating systems, constraints of green rating systems, energy conservation building code. New building technologies for affordable housing: Initiatives, Introduced Technology/system, Road ahead. Materials and Methods: Burnt bricks, stabilized mud block, Alternatives in adobe, Stabilized adobe, Concrete blocks, Alternative cements and mortars, stone in construction. Design of Walls: Some relevant issues. Roofing Technologies: Alternative roofing system, roofing system, roof based on curved surfaces. Renewable materials: Bamboo in housing and building construction, Building with bamboo, Innovations in bamboo and concrete based construction for sustainable and durable housing, timber and buildings. Construction and Demolition(C&D) Waste: Amount and utilization of C&D waste, status of C&D waste utilization standards.

Suggested Books :

1. K.S. Jagadish, Sustainable Building Technologies, BMTPC & I.K. Int. Publishing House Pvt. Ltd, 2019.
2. B. Simon and S. Morse, Sustainability Indicators: Measuring the immeasurable, Earthscan, 1998.
3. M.W. Paul, Sustainable Technology Development, Greenleaf, Sheffield, 2000.
4. D.L. Jayanetti and P.R. Follet, Bamboo in construction: An Introduction, TRADA Technology Ltd. and International Network for Bamboo and Rattan (INBAR), 1998.
5. M. Ashby, Materials and the environment, Elsevier, 2013.

STE 6203 Pre- Fabricated Structures

Types of prefabrication, prefabrication systems and structural schemes- Disuniting of structures- Structural behavior of precast structures. Handling and erection stresses, Application of prestressing of roof members; floor systems two way load bearing slabs. Wall panels, hipped plate and shell structures. Dimensioning and detailing of joints for different structural connections; construction and expansion joints. Production, Transportation & erection- Shuttering and mould design Dimensional tolerances Erection of R.C. Structures. Total prefabricated buildings. Designing and detailing prefabricated units for industrial structures, Multistory buildings and Water tanks, silos bunkers etc. Application of prestressed concrete in prefabrication.

Suggested Books :

1. A.M. Hass, Precast Concrete Design and Applications, Applied Science Publishers, 1983.
2. V. Promyslolw, Design and Erection of Reinforced Concrete Structures, MIR Publishers, 1980.

STE 6205 Form work for Concrete Structures

Introduction to Formwork as a Temporary Structure , Requirements, Selection, and Classification (Types) of Formwork, Formwork Materials, Shoring Towers, and Scaffolds, Formwork Design Concepts Conventional and Proprietary Foundation Formwork, Conventional and Proprietary Wall Formwork, Conventional and Proprietary Column Formwork Slab and Beam Formwork, Formwork for Special Structures such as Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower, Nuclear Reactor, Tunnel, and Lift Shaft. Formwork for Bridge Structures, Cases in Failure of Temporary Support Structures of Bridges, Flying Formworks such as Table Forms, Tunnel Formwork System, Column Mounted Shoring System, Gang Forms Slipform, Formwork for Precast Concrete, Formwork Failure, Pre -Award and Post –award Formwork Management Issues, Formwork Issues in Multi -Story Building Construction

Suggested Books :

1. K.N. Jha, Formwork for Concrete Structures, First Edition, McGraw Hill, 2012.
2. R.L. Peurifoy and G.D. Oberlender, Formwork for concrete structures, McGraw Hill, 2011.
3. J.R. Robinson, Piers, abutments, and formwork for bridges, Crosby Lockwood, 1964.
4. C.K. Austin, Formwork to concrete, Cleaver -Hume Press, 1960. DELHI TECHNOLOGICAL UNIVERSITY

Semester IV

STE652 Research Project

STE602 Major Project II

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Computer Science & Engineering)

Programme Specific Outcomes

Program Specific Outcomes :

1. Analyze the mathematical foundations. algorithmic principles, computer science theory for the modeling, design of computing systems in a way that demonstrates the construction of software systems of varying complexity.
2. Be prepared to work professionally in software industries, able to achieve the higher studies and develop the modern tools and communicate the technique and skills.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN COMPUTER SCIENCE & ENGINEERING (CSE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	CSE501	Advanced Database Management Systems	Core	4	3	0	2	15	25	20	40	-	17
	2	CSE503	Advanced Algorithms and Data Structures	Core	4	3	0	2	15	25	20	40	-	
Group B	3	CSE5401/5403/.....	Elective 1	Elective	4	3/2	0	2/4	15	25	20	40	-	
	4	CSE5301/5303/.....	Elective 2	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	5	CSE5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2/1	0	0/2	20/15	0/25	30/20	5040	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	CSE502	Distributed Systems	Core	4	3	0	2	15	25	20	40	-	17
	2	CSE504	Advanced Computer Networks	Core	4	3	0	2	15	25	20	40	-	
Group D	3	CSE5402/5404/.....	Elective 4	Elective	4	3/2	0	2/4	15	25	20	40	-	
	4	CSE5302/5304/.....	Elective 5	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	5	CSE5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	CSE651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	CSE601	Major Project I	Core	3						40	60		12
	2	CSE6401/6403/.....	Elective 7	Elective	4	3/2	0	2/4	15	25	20	40	-	
	3	CSE6301/6303/.....	Elective 8	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	4	CSE6201/6203/.....	Elective 9	Elective	2	2/1	0	0/2	20/15	0/25	30/20	50/40	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													
	1	CSE652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	CSE602	Major Project II	Core	12						0	100		12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	CSE5401	Artificial Intelligence and Expert Systems	Elective	4	3	0	2	15	25	20	40	-
	2	CSE5403	Data warehousing and Data Mining		4	3	0	2	15	25	20	40	-
	3	CSE5405	Design of Embedded Systems		4	2	0	4	15	25	20	40	-
	4	CSE5407	Information Retrieval		4	3	0	2	15	25	20	40	-
	5	CSE5409	Soft Computing		4	3	0	2	15	25	20	40	-
	6	CSE5411	Semantic Web		4	3	0	2	15	25	20	40	-
	7	CSE5413	Machine Learning		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	CSE5301	Advanced Computer Graphics	Elective	3	2	0	2	15	25	20	40	-
	2	CSE5303	Fault Tolerant and testable Systems		3	3	0	0	20	-	30	50	-
	3	CSE5305	VLSI Design		3	2	0	2	15	25	20	40	-
	4	CSE5307	Parallel Computer Architecture		3	3	0	0	20	-	30	50	-
	5	CSE5309	Social Media and Online Marketing		3	3	0	0	20	-	30	50	-
	6	CSE5311	Reliable System Design		3	3	0	0	20	-	30	50	-
	7	CSE5313	Robotics Engineering		3	2	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	CSE5201	SEMINAR	Elective	2	0	0	2	-	0	-	100	-
	2	CSE5203	Distributed Algorithms		2	2	0	0	20	-	30	50	
	3	CSE5205	Modeling& Simulation		2	1	0	2	15	25	20	40	-
	4	CSE5207	Multivariate Calculus		2	2	0	0	20	-	30	50	-
	5	CSE5209	Ethical Hacking		2	2	0	0	20	-	30	50	-
	6	CSE5211	Software Lab		2	1	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	CSE5402	Wireless & Mobile Communication	Elective	4	3	0	2	15	25	20	40	-
	2	CSE5404	Digital Image Processing		4	3	0	2	15	25	20	40	-
	3	CSE5406	Software Testing		4	3	0	2	15	25	20	40	-
	4	CSE5408	Computer Vision		4	2	0	4	15	25	20	40	-
	5	CSE5410	Applied Cryptography		4	3	0	2	15	25	20	40	-
	6	CSE5412	Optical Networks		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	CSE5302	MINOR PROJECT	Elective	3	-	-	-	-	40	-	-	60
	2	CSE5304	Information and Network Security		3	2	0	2	15	25	20	40	-
	3	CSE5306	Bioinformatics		3	3	0	0	20	-	30	50	-
	4	CSE5308	Big Data Analytics		3	2	0	2	15	25	20	40	-
	5	CSE5310	Security and Privacy in Social Networks		3	3	0	0	20	-	30	50	-
	6	CSE5312	Probability and Statistical Theory		3	3	0	0	20	-	30	50	-
	7	CSE5314	Business Intelligence		3	3	0	0	20	-	30	50	-
	8	CSE5316	Mobile and Cellular Network Security		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	CSE5202	Optimization Tools	Elective	2	2	0	0	20	-	30	50	-
	2	CSE5204	Statistical Tools		2	2	0	0	20	-	30	50	-
	3	CSE5206	Geo-Informatics		2	2	0	0	20	-	30	50	-
	4	CSE5208	Security Tools and Applications		2	2	0	0	20	-	30	50	-
	5	CSE5210	Secure Coding		2	2	0	0	20	-	30	50	-
	6	CSE5212	Linear Optimization		2	2	0	0	20	-	30	50	-
	7	CSE5214	Advances in Multimedia Technology		2	2	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	CSE6401	Pattern Recognition	Elective	4	3	0	2	15	25	20	40	-
	2	CSE6403	Software Project Management		4	3	0	2	15	25	20	40	-
	3	CSE6405	Cluster & Grid Computing		4	3	0	2	15	25	20	40	-
	4	CSE6407	Internet of Things		4	3	0	2	15	25	20	40	-
	5	CSE6409	Nanotechnology		4	2	0	4	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	CSE6301	Natural Language Processing	Elective	3	3	0	0	20	-	30	50	-
	2	CSE6303	Digital Forensics		3	3	0	0	20	-	30	50	-
	3	CSE6305	Game Theory		3	3	0	0	20	-	30	50	-
	4	CSE6307	Deep Learning		3	3	0	0	20	-	30	50	-
	5	CSE6309	Blockchain and applications		3	3	0	0	20	-	30	50	-
	6	CSE6311	Real Time Systems		3	2	0	2	15	25	20	40	-
	7	CSE6313	Quantum Computing		3	2	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	CSE6201	Research Methodology		2	2	0	0	20	-	30	50	-
	2	CSE6203	Enterprise Computing in JAVA		2	1	0	2	15	25	20	40	-
	3	CSE6205	Advances in Internet & Web Technology		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

CSE501 Advanced Database Management System

Relational Databases: Integrity Constraints revisited, Extended ER diagram, Relational Algebra & Calculus, Functional, Muiltivalued and Join Dependency, Normal Forms, Rules about functional dependencies. **Advanced Transaction Processing:** Nested and Multilevel Transactions, Compensating Transactions and Saga, Long Duration Transactions, Weak Levels of Consistency, Transaction Work Flows, Transaction Processing Monitors, Schedules, Serializability- conflict and view. **Query Processing:** General strategies for query processing, transformations, expected size, statistics in estimation, query improvement, view processing, query processor. **Query Optimization:** Indexing and Query Optimization, Limitations of Relational Data Model, Null Values and Partial Information. **Parallel and Distributed Databases:** Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Distributed Transaction Modeling and concurrency Control, Distributed Deadlock, Commit Protocols, Design of Parallel Databases, Parallel Query Evaluation **Active Database and Real Time Databases:** Triggers in SQL, Event Constraint and Action: ECA Rules, Query Processing and Concurrency Control, Compensation and Databases Recovery.

Suggested Books:

1. Elmarsi, Navathe, Somayajulu and Gupta, Fundamentals of Database Systems", 4th Edition, Pearson Education, 2007.
2. Garcia, Ullman and Widom, "Database Systems, The complete book", Pearson,2007
3. Date, Kannan andSwaminathan, "An Introduction to Database Systems", 8th Edition Pearson Education, 2007.
4. Silberscatz, Korth and Sudarshan, "Database System Concepts", Mcgraw Hill, 6th Edition, 2006

CSE503 Advanced Algorithms and Data Structures

Review of Elementary data structures: Binary Trees, Binary heap, Sorting and Searching techniques, Sparse matrices: Properties of sparse matrices, linked list representation of sparse matrices, analyzing algorithms. , Hashing, universal hashing, perfect hashing. **Advanced Data Structures**: data structures for combinatorial optimization - Binomial heaps, Fibonacci heaps. Red-Black Trees. Augmenting Red-Black Trees to Dynamic Order Statics and Interval Tree Applications. Operations on Disjoint sets - find union problem, Implementing Sets. Dictionaries, self-adjusting trees, skip lists. **Divide and Conquer approach-**Application of divide and Conquer-Finding Maximum and Minimum, Finding K-th smallest element Order Statistics, Finding K-th smallest element, Merge Sort, Randomized quick sort. **Graph Algorithms**: Definitions for Graphs, Algorithms for Connectedness, Finding all Spanning Trees in a Weighted Graph and Planarity Testing Breadth First and Depth First Search, Articulation Point, Cut edge, Topological Sort, Strongly Connected Components and. Single source shortest path and all pair shortest path algorithms, Planer graphs**Greedy Method and Dynamic Programming:** General Method, Knapsack problem, Single source shortest path. Job Sequencing with deadline, Scheduling problems. Dynamic Programming: General method, 0/1 Knapsack problem, All pair shortest path. Backtracking: Sum of subsets, 8-queens problem, and Hamiltonian cycles.**Advanced Algorithms**: NP Complete problems, Approximation algorithms for NP complete problem (Vertex cover, traveling salesman), , Algorithms for matching, Flow and circular problems, Bio Inspired Algorithm- Genetic Algorithm, Particle Swam, Artificial Bee Colony, Firefly Algorithm, Bat Algorithm

Suggested Books:

1. T.H. Cormen, C. E. Leiserson, R.L. Rivest, Introduction to Algorithms, MIT Press,2013
2. Aho, Hopcraft&Ulman, The Design and Analysis of Computer algorithms", Addison Wesley,1974
3. S. Dasgupta, C. H. Papadimitriou, and UV Azirani, Algorithms,2006
4. Tannenbaum, Data Structures, PHI,2004
5. R.E. Trajan,,Data Structures and Network algorithms, SIAM Regional Conference series in applied mathemetics,1983
6. E. Horowitz, S.Sahni and S. Rajasekaran The Design and Analysis of Computer Algorithms, Universities Press2003
7. R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press,1995
8. D. C. Kozan, The Design & Analysis of Algorithms, Springer,1992
9. N. Deo,Graph Theory with Application to Engineering and Computer Science, Prentice Hall of India,1979

CSE5401 Artificial Intelligence and Expert Systems

Introduction: AI Problems, Task Domains of AI, Introduction to Intelligent program and Intelligent methodologies.

AI Techniques: search knowledge, abstraction. **Problem Solving**: Basic Problem solving Method: state space search, problem characteristics, Production systems characteristics, issues in design of Intelligent search algorithm**Heuristic search Techniques**: Hill climbing techniques, Best Firstsearch, A* Search,: AO* Search, Constraint Satisfaction, Means-End Analysis.**Game Playing**: Game Tree, Searching procedure Minimax, alpha-beta pruning**Knowledge Representation**: Knowledge Representation issues.**Knowledge Representation:** usingPredicate Logic: Unification, resolution.Natural deduction, using Rules: Forward versus backward reasoning, conflict resolution. **Structured Knowledge Representation**: Semantic Nets, Frames, conceptual dependency, scripts. **Programming Languages:**Prolog or Lisp implementation of inferences for above knowledge representation methods**Symbolic Reasoning under uncertainty**: Introduction to Non-Monotonic Reasoning, Logics for non monotonic reasoning such as Default reasoning; Minimalist reasoning; implementation issues.**Statistical Reasoning**: Probabilistic Reasoning, CertaintyFactors and Rule Based Reasoning, Bayesian Network, Dempster Shafer Theory, Fuzzy logic**Learning**. Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, **Learning:** Neural Network, Genetic theorem**Introduction to machine LearningApplications: Expert Systems**: Architecture, Domain Knowledge, Knowledge Acquisition, Case Studies: MYCIN, RI,**Natural language Processing**: Syntactic, Semantic and Pragmatic Analysis.**Research issues** in different domains

Suggested Books:

1. E. Rich and K. Knight, Artificial Intelligence, TMH, 2nd ed,1992
2. N.J. Nilsson, Narosa Publication. House, Principles of AI, 1990
3. M.Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (2nd Edition) Addison-Wesley,2005.
4. D.W. Patterson, "Introduction to AI and Expert Systems", PHI, 1992.

CSE5403 Data Warehousing and Data Mining

Data Warehousing: - Basic concepts in data warehousing, Collecting the requirements of data warehouse, Data Warehouse Architecture, Design, Implementation & Maintenance, OLAP in data warehouse, Data warehousing and the web, Data Cube Technology, From Data Warehousing to Data Mining. **Data Mining Concepts:** Data mining primitives, Basics of data mining, Query language, Architectures of data mining systems. **Mining Association Rules in Large Databases:**Association Rule Mining, Mining Single Dimensional Boolean Association Rules from Transactional Databases, Mining Multilevel Association Rules from Transaction Databases, Mining Multidimensional Association Rules from Relational Databases and Data Warehouses, From Association Mining to Correlation Analysis, Constraint Based Association Mining. **Classification and Prediction:** Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Classification by Back propagation, Classification Based on Concepts from Association Rule Mining, Other Classification Methods, Prediction, Classifier Accuracy. **Cluster Analysis in Data Mining:** Types of Data in Cluster Analysis. A Categorization of Major Clustering Methods, Partitioning Methods, Density Based Methods, Grid Based Methods; Model Based Clustering Methods, Outlier Analysis. **Mining Complex Types of Data:** Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases. **Applications and trends in Data Mining: -** Applications, Systems products and research prototypes, Additional themes in data mining, Trends in Data mining, spatial mining, and Web Mining.

Suggested Books:

1. P. Ponnian,Data Warehousing Fundamentals, John Wiley
2. M.H. Dunham, Pearson Education,Data Mining Introductory & Advanced Topics, 2011.
3. H. Kamber, M. Kaufman, Data Mining Concepts & Techniques, Elsevier, 2011.
4. R. Kimball,The Data Warehouse Lifecycle Tool Kit, John Wiley, 2012.
5. M. Berry , G. Linoff,Master in Data Mining, John Wiley, 1996.

CSE5405 Design Of Embedded Systems

Introduction to Embedded Real time Systems: Fundamental components of ESD, Preprocessing, Compiling, crosscompiling, Linking, Locating, compiler driver, Linker script, Program segmentsType of memory, Memory Management in Embedded real time systems, Interrupt and ISR, Introduction to Real-time theory: Scheduling theory, Rate Monotonic Scheduling, Utilization bound theorem, RTOSTask Management, Task management, Race condition, Priority inversion, ISRs and scheduling, Inter-Task communication, TimersMicrocontrollers: Role of processor selection in Embedded System (microprocessor vs microcontroller), 8051 microcontroller: architecture, assembly language programming, instruction set, addressing mode, logical operation, arithmetic operation, interrupt handling, Timing subroutinesSerial data communication, RS-232, USB, I2C, Interfacing with ADC & sensors, Interfacing with DAC, Interfacing with external ROM, Interfacing with 8255 IEEE 1149.1 (JTAG) testability: Boundary Scan Architecture.

Suggested Books:

1. S. V Iyer and P. Gupta, Embedded Real-time Systems Programming, TMH,2003
2. Mazidi and Mazidi, The 8051 Microcontroller, PHI. 2007

3. R. Kamal ,Embedded System , TMH,2017

4. K. J. Ayala, T. DelMar ,The 8051 Microcontroller,1996

5. A. Deshmukh, Microcontrollers, TMH, 2017.

6. R. Kapadia, 8051 Microcontroller & Embedded systems,Jacio publishing house,2004

7. wayne wolf, Computer as components, Harcourt India Pvt. Ltd., 2008.

8. Philip A. Laplante,Real time System and Analysis,Wiley; 3rd edition (11 May 2004)

CSE5409 Soft Computing

Soft Computing & Artificial Intelligence: Soft Computing Introduction, Hard Computing, Types of Soft Computing Techniques, Applications of Soft Computing, AI Search Algorithm, Predicate Calculus, Rules of Interference, Semantic Networks, Frames, Objects, Hybrid Models **Artificial Neural Networks :** History, overview of biological Neuro-system, Neuron Model, Neural Network Architecture, Learning Rules, Perceptrons, Single Layer Perceptrons, Multilayer Perceptrons, Back propagation Networks: Kohnen'sself organizing networks, Hopfield network, Applications of NN **Fuzzy Logic and Fuzzy Sets :** Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations, Overview of Classical Sets, Membership Function, Fuzzy rule generation **Fuzzy Arithmetic:** Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. **Neuro - Fuzzy Modeling** : Neuro Fuzzy Controls ,Adaptive Networks Based Fuzzy Interface Systems, Classification and Regression Trees, Data Clustering Algorithms, Rule Based Structure Identification, Evolutionary Computation **Genetic Algorithms and Swarm Optimizations:** Introduction to Genetic Algorithm, Fitness Computations, Evolutionary Programming, Genetic Programming Parse Trees, Variants of GA, Applications, Ant Colony Optimization, Particle Swarm Optimization, Artificial Bee Colony Optimization.

Suggested Books:

1. Anderson J.A., An Introduction to Neural Network, PHI, 1995.

2. S.Patnaik, B.Zhong, Soft Computing Techniques in Engineering Applications,Springer 2014

3. Hertz J. Krogh, R.G. Palmer, Introduction to the Theory of Neural Computation, Addison-Wesley, 1991.

4. G.J. Klir& B. Yuan, Fuzzy Sets & Fuzzy Logic, PHI, 1995.

5. M. Mitchell, An Introduction to Genetic Algorithm, PHI, 1998.

6. S. Kaushik, Artificial Intelligence, Cengage Learning, 2007..

CSE5411 Semantic Web

Semantic Web Vision: Todays' web, Examples of semantic web from today's web, Semantic web technologies, layered approach. **Structured web documents in XML**: The XML language, Structuring, Namespaces, Querying and Addressing XML documents, Processing. **Describing Web Resources**: Introduction, RDF , RDF Schema syntax and language, Direct Inference System, Querying RQL. **Web Ontology Language**: Introduction, OWL language, Examples, OWL in OWL, Future extensions. **Logic and Inference**: Rules: Introduction, Monotonic Rules syntax, semantics & examples, Nonmonotonic rules – syntax & examples, Encoding in XML. **Ontology Engineering**: Introduction, Manual construction of Ontology, Reusing existing ontology, using Semi-automatic methods, Knowledge semantic web architecture. **Applications & Future trends:** Various applications, Issues and future trends.

Suggested Books:

1. P. Hitzler, M. Krötzsch, Foundations of Semantic Web Technologies, CRC Press,2009
2. G.Antoniou and F.Hermelen ,A Semantic web Primer, MIT Press,2004
3. John Hebler ,Semantic Web programming, Wiley,2009

CSE5301 Advanced Computer Graphics

Line Drawing and transformation: Basic raster graphical algorithm for 2D primitives, Line drawing algorithm, 2D and 3D transformation**Clipping:** Window, View port, clipping algorithm. **Curves and Surfaces:** Circle drawing algorithm, Ellipse drawing algorithm, Bezier curve, b-spline curve, surfaces, Solid modelling. **Projection:** Parallel projection, Perspective projection, Computation of vanishing point. **Visible surface determination:** Z-buffer algorithm, Scan line algorithm, Area subdivision algorithm, Raytracing algorithm. **Shading:** Illumination mode, Specular reflection model, Shading models for curve surfaces, Radiosity method, Rendering, Recursive ray tracing, Texture mapping Advanced Modelling Techniques Procedural Models,FractalModels,Grammar based models,particle systems. **Animation:** 3D animation, morphing, simulation of key frames.

Suggested Books:

1. Foley,Computer Graphics Principles & Practice, 2nd ed. Pearson Education,2014
2. Hearn &Baker , Computer Graphics C version, 2nd ed. Pearson Education,2002
3. Ro and Adams , Mathematical Element for Computer Graphics, 2nd ed., Tata McGraw Hill,1984
4. D. F. Rogers, Procedural Element for computer graphics, McGraw Hill Book Company,2016
5. W. A. and M. Watt, Advanced Animation and Rendering Techniques Theory and Practice, Addison-Wesley,1992
6. A. K. Peters, P. Shirley, Fundamentals of Computer Graphics, 3rd ed. CRC Press,2009

CSE5303 Fault Tolerant and Testable Systems

Fundamental Concepts: Definitions of fault tolerance, fault classification, fault tolerant attributes and system structure. Faults and their causes Common Fault Models, Common Error Models. **Fault-Tolerant Design Techniques:** Information redundancy, hardware redundancy, and time redundancy. **Architecture of Fault-Tolerant Computers (case study):** General-purpose systems, high-availability systems, long-life systems, critical systems. **Software Fault Tolerance:** Software faults and their manifestation, design techniques, reliability models..**Fault Tolerant Parallel/ Distributed Architectures:** Shared bus and shared memory architectures, fault tolerant networks. **Recent topics in fault tolerant systems:** Security, fault tolerance in wireless/mobile networks..

Suggested Books:

1. D.K. Pradhan,Fault-Tolerant Computer System Design, Prentice Hall, 1996.
2. B.W.Johnson, Design and Analysis of Fault Tolerant Digital System, Addison-Wesley, 1989.
3. D.K. Pradhan, Fault-Tolerant Computing: Theory and Techniques Vol. I,II, Prentice-Hall, 1986.
4. D.P. Siewiorek and R.S. Swarz , Reliable Computer Systems Design and Evaluation, AK Peters Ltd,1998.

5. K.S.Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Application, Prentice Hall, 2001.

CSE5305 VLSI Design

Introduction to CMOS circuits: MOS Transistors, MOS transistor switches, CMOS Logic, The inverter, Combinational Logic, NAND gate, NOT Gate, Compound Gates, Multiplexers, Memory-Latches and RegistersProcessing Technology: Silicon Semiconductor Technology-An Overview, wafer processing, oxidation, epitaxy deposition, Ion-implantation and diffusion, The Silicon Gate Process- Basic CMOS Technology, basic n-well CMOS process, p-well CMOS process, Twin tub process, Silicon on insulator, CMOS process enhancement-Interconnect, circuit elements, 3-D CMOS. Layout Design Rule: Layer Representations, CMOS n-well Rules, Design Rule of background scribe line, Layer Assignment, SOI RulePower Dissipation: Static dissipation, Dynamic dissipation, short-circuit dissipation, total power dissipation. Programmable Logic, Programmable Logic structure, Programmable interconnect, and Reprogrammable Gate Array: Xilinx Programmable Gate Array, Design Methods: Behavioral Synthesis, RTL synthesisPlacement: placement: Mincut based placement – Iterative improvement placement simulated annealing. Routing: Segmented channel routing – maze routing – routability and routing resources – net delaysVerification and Testing: Verification Versus Testing, Verification: logic simulation design validation – timing verification – Testing concepts: failures – mechanisms and faults – fault coverage – ATPG methods – types of tests – FPGAs – programmability failures – design for testability.Overview of VHDL

Suggested Books:

1. J.M. Rabaey, A.P. Chadrakasan and B. Nikolic, Digital integrated circuits a design perspective, Pearson Education, 2012.

2. S.M.O. Kang and Y. Leblebici, CMOS digital integrated circuits, Tata McGraw Hill Publication, 2014.

3. Wayne Wolf "Modern VLSI Design", Prentice Hall, 2002.

4. N. Sherwani, "Algorithm for VLSI Design & Automation", Springer, 1998

5. Bhaskar, "VHDL", PHI, 1999.

CSE5307 Parallel Computer Architecture

Parallel computer models: The state of computing, Classification of parallel computers, Multiprocessors and multicomputers, Multivector and SIMD computers. **Program and network properties:** Conditions of parallelism, Data and resource Dependences, Hardware and software parallelism, Program partitioning and scheduling, Grain Size and latency, Program flow mechanisms, Control flow versus data flow, Data flow Architecture, Demand driven mechanisms, Comparisons of flow mechanisms. **System Interconnect Architectures:** Network properties and routing, Static interconnection Networks, Dynamic interconnection Networks, Multiprocessor system Interconnects, Hierarchical bus systems, Crossbar switch and multiport memory, Multistage and combining network. **Advanced processors:** Advanced processor technology, Instruction-set Architectures, CISC Scalar Processors, RISC Scalar Processors, Superscalar Processors, VLIW Architectures, Vector and Symbolic processors. **Pipelining:** Linear pipeline processor, nonlinear pipeline processor, Instruction pipeline Design, Mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch Handling techniques, branch prediction, Arithmetic Pipeline Design, Computer arithmetic principles, Static Arithmetic pipeline, Multifunctional arithmetic pipelines. **Memory Hierarchy Design:** Cache basics & cache performance, reducing miss rate and miss penalty, multilevel cache hierarchies, main

memory organizations, design of memory hierarchies. **Multiprocessor architectures:** Symmetric shared memory architectures, distributed shared memory architectures, models of memory consistency, cache coherence protocols (MSI, MESI, MOESI), scalable cache coherence, overview of directory based approaches, design challenges of directory protocols, memory based directory protocols, cache based directory protocols, protocol design tradeoffs, synchronization. **Scalable point – point interfaces:** Alpha364 and HT protocols, high performance signaling layer.

Suggested Books:

1. Kai Hwang, Advanced computer architecture; TMH,2010.
2. D. A. Patterson and J. L. Hennessey, Computer organization and design,2010
3. J.P.Hayes,Computer Architecture and organization; T.MH,2012
4. Harvey G.Cragon, Memory System and Pipelined processors, Narosa Publication,1996
5. V.Rajaranam&C.S.R.Murthy, Parallel computer"; PHI. ,2000
6. R.K.Ghose, R Moona& P. Gupta, Foundation of Parallel Processing, Narosa Publications,1996
7. K. Hwang and Zu, Scalable Parallel Computers Architecture, MGH. ,2000
8. Stalling W, Computer Organisation & Architecture, and PHI,2004

CSE5309 Social Media and Online Marketing

Social media marketing, platforms and strategies, active and passive approach, purpose and tactics, marketing techniques, implications on traditional advertising, leaks and mishaps Digitala dvertising, Display advertising, web banner advertising, mobile advertising, email advertising, classified advertising, affiliate marketing, content marketing, benefits of online advertising, security concerns and technological concerns, regulatory acts Marketing management, brandauditing, marketing planning and implementation strategy, Social media in business,importance of social media in entreprenurship and business success,businessmanagement,social media and business management strategiesWebsites and its levels, difference between blogs, portals, and websites. Static and dynamic websites, News Writing and SEO-onpage and off page optimizationsSocial Media Optimizations, SMM:An Overview, Theoretical Concepts Guiding Social Media, Social Media Strategy and Planning, Social Media Measurement.Content Strategy, Blogging and Microblogging, Social Bookmarking, Social Media Sites(SNS): LinkedIn & Twitter, SNS: Photosharing Sites(Instagram,Snapchat, Pinterest), SNS: Facebook for business, SNS:Youtube and Live Streaming

Suggested Books:

1. "Social Media Marketing: Principles and Strategies", Stephen, A. & Bart, Y. (2017)
2. "Social PR Secrets: How to Optimize, Socialize, and Publicize Your Brand." 3rd edition, Buyer, (2016)
3. Digital and social media marketing-A result driven approach by Heinzei,Rashid and Cruz 1st edition
4. The New Rules of Marketing & PR-David scott 5th edition
5. The New Rules of Marketing & PR: How to Use Social Media, Online Video, Mobile Applications, Blogs, News Releases, and Viral Marketing to Reach Buyers Directly

CSE5311 Reliable System Design

Fundamental Concepts Definitions of fault tolerance, fault classification, fault tolerant attributes and system structure. **Fault-Tolerant Design Techniques** Information redundancy, hardware redundancy, and time redundancy. **Dependability Evaluation Techniques**.Reliability and availability models: (Combinatorial techniques, Fault-Tree models, Markov models), Performance Models.**Architecture of Fault-Tolerant Computers (case study)** General-purpose systems, high-availability systems, long-life systems, critical systems. **Software Fault Tolerance**.Software faults and their manifestation, design techniques, reliability models.**Fault Tolerant Parallel/Distributed Architectures**Shared bus and shared memory architectures, fault tolerant networks. Recent topics in fault tolerant systems:Security, fault tolerance in wireless/mobile networks.

Suggested Books:

1. D.K. Pradhan, Fault, Tolerant Computer System Design ,Prentice-Hall2003
2. B.W. Johnson, Design and Analysis of Fault-Tolerant Digital Systems, Addison-Wesley
3. D.K. Pradhan, Fault, Tolerant Computing, Theory and Techniques, Volumes I and II, Prentice Hall,2003
4. D.P.Siewiorek and R.S.Swartz ,Reliable Computer Systems: Design and Evaluation, Digital Press, 1992.
5. K.S.Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Application, Prentice Hall, 1982

CSE5313 Robotics Engineering

Introduction to Robotics Engineering: History of robots, Classification of robots, Present status and future trends,Basic components of robotic system, Basic terminology- Accuracy, Repeatability, Resolution, Degree of freedom, Mechanisms and transmission, End effectors: Grippers-different methods of gripping, Mechanical and other types of grippers, Tools as end effectors, Robot and effector interface, Gripper selection and design, Specifications of robot. **Drive systems and Sensors:** Drive system- hydraulic, pneumatic and electric systems Sensors in robot – Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision sensor, Force sensor, Light sensors, Pressure sensors. **Kinematics and Dynamics of Robots:** 2D, 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple transformation, Simple problem, Matrix representation, Forward and Reverse Kinematics Of Three Degree of Freedom, Homogeneious Transformations, Inverse kinematics of Robot, Robot Arm dynamics, D-H representation of robots, Basics of Trajectory Planning,Robot Dynamics: Lagrangian Mechanics, Lagrangian Formulation and numericals, Dynamics, Newton-Euler Recursive Algorithm, Simulation, Euler-Lagrange Equations of motion/Any one other formulation like using Decoupled Natural Orthogonal Complements (DeNOC). **Robot Controls and Programming:** Robot controls-Point to point control, Continuous path control, Intelligent robot, Control system for robot joint, Control actions, Feedback devices, Encoder, Resolver, LVDT, Motion Interpolations, Adaptive control,Introduction to Robotic Programming, On-line and off-line programming, programming examples. **Applications for Manufacturing:** Flexible automation, Robot cell layouts, Machine interference, Other considerations in work cell design, Work cell control, interlocks, Robot cycle time analysis, Mechanical design of robot links,Typical applications of robots in material transfer, machine loading/unloading; processing operations; assembly and inspection.

Suggested Books:

1. M. P Groover, N.G Odrey, M. Weiss, R.N Nagel, Technology programming and Applications, McGraw Hill, 2012.
2. Craig. J. J., Introduction to Robotics- mechanics and control, Addison- Wesley, 1999.
3. Saha, S.K., Introduction to Robotics, 2nd Edition, McGraw-Hill Education, New Delhi, 2014
4. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education., 2009..
5. R. D. Klafter, Thomas. A, C.Elewski, M. Negin, Robotics Engineering an Integrated Approach, PHI Learning., 2009
6. R. Asfahl. C, Robots and Manufacturing Automation, John Wiley & Sons Inc.,1985.
7. Fu. K. S., Gonzalez. R. C. & Lee C.S.G, Robotics control, sensing, vision and intelligence, McGraw Hill Book co, 1987

CSE5201 SEMINAR

CSE5203 Distributed Algorithms

Introduction: Algorithmic challenges of distributed algorithms) ; Basic definitions (System models, distributed computation, local/global states, consistency, complexity measures) .Time in distributed computing (logical clocks, vector clocks, virtual time) ; Distributed graph algorithms (Spanning trees, broadcast & converge cast, shortest path)Distributed mutual exclusion algorithms ; Global state and snapshot recording algorithmsMonitoring global states (Necessary & sufficient conditions for consistent global states, zig-zag paths) ; Termination Detection (Based on snapshots computations, weight throwing, spanning trees)

Suggested Books:

1. A. Kshenkalyani/ M.Singhal: Distributed Computing, Cambridge University Press, 2008
2. Wan Fokkink: Distributed Algorithms: an Intuitive Approach, MIT Press, 2013
3. David Peled: Distributed Computing: a Locality Sensitive Approach, SIAM Monograph, 2000
4. Nancy Lynch: Distributed Algorithms, Morgan Kaufmann, 1996
5. M. Raynals: Distributed Algorithms for Message-Passing Systems, Springer, 2013.

CSE5205 Modeling& Simulation

System definition and components: stochastic activities, continuous and discrete systems, system modeling, types of models, static and dynamic physical models.Types of system simulation: Real time simulation, Hybrid simulation, simulation of pure-pursuit problem, single-server queuing systemIntroduction to SIMSCRIPT: Program, system concepts, origination, and statements, defining the telephone system model.Simulation of PERT Networks: critical path computation, uncertainties in activity duration, resource allocation and consideration.Simulation languages and software.

Suggested Books:

1. Geoffrey Gordon, System Simulation, PHI,2011
2. J. Banks, John S. C Barry L. Nelson David M. Nicol, "Discrete Event System Simulation", Pearson Education,2010

3. V P Singh, System Modelling and simulation, New Age International,2009

4. Averill M. Law, W. David Kelton, System Modelling and simulation and Analysis, TMH

CSE5207 Multivariate Calculus

Functions, Gradients and derivatives, product rule, chain rule, variables, constants and context, differentiation with respect to different variables.Vectors of derivatives: Jacobian, calculation and applications of Jacobian, Hessian, calculation and applications of HessianMultivariate chain rule, Application in neural network: neuron, simple neural network, training neural network,backpropagation. Taylor Series for approximation: Building approximate functions, power series, visualization of Taylor series, power series derivative and details, applications of Taylor series, Linearization, Multivariate Taylor series.Fitting as minimization problem: Newton-Raphson in one dimension, Gradient descent, constraint optimization, Lagrange multipliers

Suggested Books:

1. Roger A. Horn, Charles R. Johnson, Matrix Analysis (2nd ed.), Cambridge University Press, 2013.

2. Dimitri P. Bertsekas, John N. Tsitsiklis,Introduction to Probability (2nd ed.). Athena Scientific, 2008.

3. Trevor Hastie, Robert Tibshirani, Jerome Friedman,The Elements of Statistical Learning (2nd ed.), Springer, 2008

CSE5209 Ethical Hacking

Introduction to ethical hacking:-Introduction-Ethical hacking Terminology-types of hacking technologies-phases of ethical hacking-Footprinting-Social Engineering-Scanning and enumeration. **System hacking:-** Understanding the password hacking techniques-Rootkits-Trojans- Backdoors-Viruses and worms-sniffers-denial of service-Session hijacking. **Web server hacking:-**Hacking web servers-web application vulnerabilities –Buffer overflow-Wireless hacking Physical Security. **Wireless hacking**:- WEP, WPA Authentication mechanism-wireless sniffers-Physical Security-factors affecting physical security-honey pots-Firewall types. **Penetration testing:-**Cryptography-overview of MD5, SHA, RC4-penetration testing methodologies- steps-pen test legal framework-penetration testing tools.

Suggested Books:

1. P. Engebretson, The Basics of Hacking and Penetration Testing, Elsevier, 2013

2. R. Khare, Network Security and Ethical Hacking, Luniver Press, 2006

3. Michael T. Simpson, K. Backman, J Corley, Hands-On Ethical Hacking and Network Defence

4. S. DeFino, B. Kaufman, N Valenteen, Official Certified Ethical Hacker Review Guide

5. The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made Easy Syngress Basics Series

6. Hands-On Ethical Hacking and Network Defence.

CSE5211 Software Lab

SEMESTER II

CSE502 Distributed Systems

Introduction:Distributed System Models, Transparency, Scalability, Inter-process Communication, Middleware, issues in design of Distributed systems: current &future.Communications: Layered Protocol, Distributed Objects & Remote Method Invocation, Remote Procedure Call, Synchronization in communication, sockets, MPI, Message brokers, Data Streams.Process and Synchronization: Processes, Threads, Code Migration, Logical clocks, vector clocks, direct dependency clocks, matrix clocks, Serializability.Resource Allocation: Distributed Shared Memory, Process Scheduling, Load Balancing & Load Sharing, Mutual Exclusion, Election algorithms.Distributed File Systems: Coordination & Agreement, Distributed Transaction, Consistency & Replication: Consistency Models, Distribution &Consistency Protocols. Distributed Systems: Google Case Study with Map ReduceDistributed Systems: Security:Overview of security techniques, Cryptographic algorithms , Digital signatures, Cryptography pragmatics, Case studies: Needham–Schroeder, Kerberos, TLS, 802.11

Suggested Books:

1. A.S. Taenbaum and M. Van Steen, "Distributed Systems: Principles and Paradigms", Prentice Hall, 2016.
2. G. Coulouris and J. Dollimore, Distributed Systems Concepts and Design, Addison Wesley,2006.
3. A. Kshenkalyani and M.Singhal, Distributed Computing, Cambridge University Press, 2008.

CSE504 Advanced Computer Networks

Basic networking concepts : introduction to networks, layering and link layer, network layer, routing, end-to-end layer, congestion control. **Modeling and measurement**: network traffic modeling, network measurement, simulation issues, network coding techniques.Routing and router design, scheduling and QoS, integrated and differentiated services, RSVP.Wireless networks and mobility supports, MAC protocol, routing, AODV, group communication, multicast Flow and congestion control, TCP variants, TCP modeling, active queue management. **Overlay networks**: RON, P2P, CDN, Web caching, cross-layer optimizations, Emerging network types: data center, DTN, 4G mobile networks (LTE, Wi-Max), Online social networks (OSN), wireless sensor networks (WSN) – cross-layer sensor data dissemination. .**Emerging applications :** VoIP, SIP, video over P2P.

Suggested Books:

1. J.F. Kurose and K.W. Ross, Computer networking: A top-down approach, 6th edition,Adison Wesley, 2012.
2. L.L. Peterson and B.S. Davie, Computer Networks ISE: A System Approach, 5th edition,Morgan Kaufman, 2007.
3. B.A. Forouzan, Data communication & networking, 5th Edition, Tata Mc-Graw Hills, 2000.

CSE5402 Wireless & Mobile Communication

Introduction: Network Technologies and Cellular Communications, Discussion on Bluetooth & GSM. Introduction to Mobile Computing: novel applications, limitations, and architecture. **(Wireless) Medium Access Control**: Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.Bluetooth (User scenarios, physical layer, MAC layer, networking, security, link management) **Mobile Architecture:** Mobile Network Layer: Mobile IP

(Goals, assumptions, entities and terminology, IP packet delivery, agent advertisement and discovery, registration, tunneling and encapsulation, optimizations), Dynamic Host Configuration Protocol (DHCP). **Mobile Transport Layer:** Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/fast recovery, Transmission /time out freezing, Selective retransmission, Transaction oriented TCP .**Mobile Ad hoc Networks (MANETs):** Overview, Properties of a MANET, spectrum of MANET applications, routing and various routing algorithms, security in MANETs. Wireless Sensor Networks- Basic Characteristics of WSNs- Operating Systems for WSNs. **Protocols and Tools:** Wireless Application Protocol WAP. (Introduction, protocol architecture, and treatment of protocols of all layers) ,J2ME and Latest Technologies

Suggested Books:

1. R. Kamal, Mobile Computing,Oxford Higher education, Second Edition, 2002.
2. W. Stallings,Wireless Communication and Networks, Pearson Education, 2003.
3. V. Garg and J. Wilkes, Wireless and Personal Communications Systems, Prentice-Hall, Englewood Cliffs, NJ, 1996.
4. L. Merk, M.S. Nicklaus and T. Stober, Principle of Mobile Computing, Second Edition, Springer, 2003.
5. D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
6. J. Schiller, Mobile Communication, Addison Wesley, 2000.

CSE5404 Digital Image Processing

The origins of Digital Image Processing. Examples of Fields that Use Digital Image Processing, Fundamentals Steps in Image Processing, Elements of Digital Image Processing Systems, Image Sampling and Quantization, Some basic relationships like Neighbors, Connectivity, Distance Measures between pixels, Linear and Non Linear Operations. **Image Enhancement in the Spatial Domain.** Some basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic and Logic operations, Basics of Spatial Filters, Smoothening and Sharpening Spatial Filters, Combining Spatial Enhancement Methods. **Image Enhancement in the Frequency Domain.** Introduction to Fourier Transform and the frequency Domain, Smoothing and Sharpening Frequency Domain Filters, Homomorphic Filtering. **Image Restoration.** A model of The Image Degradation / Restoration Process, Noise Models, Restoration in the presence of Noise Only Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of Degradation Function, Inverse filtering, Wiener filtering, Constrained Least Square Filtering, Geometric Mean Filter, Geometric Transformations. **Image Compression.** Coding, Interpixel and Psychovisual Redundancy, Image Compression models, Elements of Information Theory, Error free comparison, Lossy compression, Image compression standards. **Image Segmentation.** Detection of Discontinuities, Edge linking and boundary detection, Thresholding, Region Oriented Segmentation, Motion based segmentation. Representation, Boundary Descriptors, Regional Descriptors, Use of Principal Components for Description, Introduction to Morphology, Some basic Morphological Algorithms.

Suggested Books:

1. Jayaraman, Digital image processing, Tata Mcgraw Hill, 2011
2. R.C. Gonzalez and R.E. Woods, Digital Image Processoing (3rd Edition), 2007.

CSE5406 Software Testing

Introduction: Software Failures, Testing Process, Some Terminologies, Limitations of Testing, The V Shaped Software Life Cycle Model. **Functional Testing:** Boundary Value Analysis, Equivalence Class Testing,Decision Table Based Testing, Cause Effect Graphing Technique.Essentials of Graph Theory :- Graph introduction, Matrix Representation of Graphs, Paths and Independent Paths, Generation of a Graph from Program, Identification of Independent Paths. **Structural Testing:** Control Flow Testing, Data Flow Testing, Slice Based Testing, Mutation testing. **Software Verification:** Verification Methods, Software Requirements Specification (SRS) Document, Software Design Description (SDD) Document, Source Code Reviews, User Documentation Verification. **Selection, Minimization and Prioritization of Test Cases for Regression Testing:** Regression Testing, Regression Test Cases Selection, Reducing the Number of Test Cases, Risk Analysis, Code Coverage Prioritization Technique. **Software Testing Activities:** Levels of Testing, Debugging, Software Testing Tools, Software Test Plan. **Metrics and Models in Software Testing:** Software Metrics, Categories of Metrics, Object Oriented Metrics Used in Testing, Measures during testing, Software Quality Attributes Prediction Models.

Suggested Books:

1. Y. Singh, "Software Testing", 1st Ed., Cambridge University Press,2012.
2. P.C. Jorgenson, Software Testing A Craftsman's approach, CRC Press,1997.
3. B. Beizer, "Software Testing Techniques", Second Volume, Second Edition, Van Nostrand Reinhold, 1990.
4. B. Beizer, "Software System Testing and Quality Assurance", Van Nostrandeinhold, New York,1984.
5. G. Myers, "The Art of Software Testing", John Wiley & Sons Inc., New York,1979.
6. L. Tamres, "Software Testing", Pearson Education Asia,2002.

CSE5408 Computer Vision

Introduction to Computer Vision: Role of Artificial Intelligence and Image processing in Computer Vision, Industrial Machine Vision Applications, System Architecture, Stages of Computer Vision, State of the art. **Visual Sensors:** Camera sensors, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing, 2D/3D Geometric transformations, Homography, Feature descriptors- SIFT, Ransac, Camera Calibration: Interior and Exterior Calibration. **Feature Extraction:** Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT. **Image Representation:** Adaptive basis- Principal Component Analysis (PCA) and Independent Component Analysis (ICA), **Image Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection. **Pattern Analysis:** Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification:Discriminant Function, Supervised, Un-supervised, Semi-

supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods. **Motion and Tracking:** Detection and tracking of point features, Optical flow, Tracking-Lucas Kanade&Tomasi method (LK Tracker), **Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Suggested Books:

1. Forsyth and J. Ponce, Computer Vision: A Modern Approach, D. A. Pearson Education, 2003.
2. M. Sonka, V. Hlavac and R. Boyle, "Image Processing, Analysis, and Machine Vision" 3rd Edition, Cengage Learning, 2008.
3. R. Hartley and A. Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004.
4. R.Szeliski, Computer Vision: Algorithms and Applications, Springer Verlag London Limited 2011.
5. K. Fukunaga, Introduction to Statistical Pattern Recognition, Second Edition, Academic Press, Morgan Kaufmann, 1990.

CSE5410 Applied Cryptography

Cryptography Theory, Foundations and applications of modern cryptography. Steganography, One-way functions.Number Theory Basics: Modular arithmetic, primes, GCD and Chinese remainder theorems. Encryption; authentication; Stream Ciphers: Encryption and decryption with Stream ciphers; Block Ciphers: DES, AES, Double and triple encryptions.Symmetric cryptography, asymmetric cryptography; Public Key Cryptography: RSA, Diffe-Hellman Key exchange, digital signatures, Hash functions, Message Authentication Codes.Remote user authentication, notions of security; zero knowledge/ interactive proofs, multi-party cryptographic protocols, key exchange and applications. Crypotanalysis of cryptographic primitives and protocols, such as by side-channel attacks, differential cryptanalysis, or replay attacks; and cryptanalytic techniques on deployed systems etc.

Suggested Readings:

1. Kahate and Atul,"Cryptography and Network Security." Tata McGraw Hill, 2007.
2. W. Stalling, Cryptography and Network Security, PHI, 2013.
3. B.A. Forouzan, Cryptography,TMH
4. Mogollon and Manuel, Cryptography & security services, Mechanism & application, Cyber tech. Pub, 2008.
5. Delfs and Hans, "Introduction to cryptography." Springer, 2004.
6. Stalling, Cryptography and hardware security, W PHI,

CSE5412 Optical Networks

Optical fiber fundamentals: Solution to Maxwell's equation in a circularly symmetric step index optical fiber, linearly polarized modes, single mode and multimode fibers, concept of V number, graded index fiber.Total number of guided modes (no derivation), polarization maintaining fibers, attenuation mechanisms in fibers, dispersion in single mode and multimode fibers, dispersion shifted and dispersion flattened fibers, attenuation and dispersion limits in fibers, Kerr nonlinearity, self phase modulation, combined effect of dispersion and self phase modulation, nonlinear Schrodinger

equation (no derivation), fundamental soliton solution.**Optical sources:** LED and laser diode, principles of operation, concepts of line width, phase noise, switching and modulation characteristics – typical LED and LD structures.**Optical detectors:** P-N detector, pin detector, avalanche photodiode – Principles of operation, concepts of responsivity, sensitivity and quantum efficiency, noise in detection, typical receiver configurations (high impedance and transimpedance receivers).**Optical amplifiers:** Semiconductor amplifier, rare earth doped fiber amplifier (with special reference to erbium doped fibers), Raman amplifier, Brillouin amplifier – principles of operation, amplifier noise, signal to noise ratio, gain, gain bandwidth, gain and noise dependencies, intermodulation effects, saturation induced crosstalk, wavelength range of operation.

Suggested Books:

1. L. Kazovsky, S. Benedetto and A.Willner,Optical Fiber Communication Systems', Artech House, 1996.
2. J. Senior,Optical Fiber Communications, PHI, 2009.
3. SilvelloBetti, G. De Marchis and E. Iannone, `Coherent Optical Communications Systems', John Wiley, 1995.

CSE5302 MINOR PROJECT

CSE5304 Information and Network Security

Introduction to Data Security: General Security Principles, Communication Security, Design of Secure System. classical encryption techniques substitution ciphers and transposition ciphers, cryptanalysis, stereography, stream and block ciphers, Intruders, Viruses and related threads. **Conventional Encryption Principles:** Conventional encryption algorithms, cipher block modes of operation, location of encryption devices, key distribution Approaches of Message Authentication, Secure Hash Function and HMAC. **Modern Block Ciphers:** Block ciphers principals, Shannon's theory of confusion and diffusion, fiestal structure, data encryption standard(DES), strength of DES, cryptanalysis of DES, block cipher modes of operations, triple DES, IDEA encryption and decryption, strength of IDEA, key distribution. **Public-key cryptography Principles**: Recent Public key cryptography algorithms such as RSA, DSS etc., digital signatures, digital Certificates, Certificate Authority and key management Kerberos, X.509 Directory Authentication Service. **Latest Trends and solutions in Information Security:** Web Security, Firewall Design Principles, Trusted Systems, Intrusion Detection System. Recent trends in cryptosystem. **IP Security:** Architecture, Authentication header, Encapsulating security payloads, combining security associations, key management. **Web Security:** Secure Socket Layer(SSL) and transport layer security, TSP, Secure Electronic Transaction (SET), Electronic money, WAP security, firewall design principals, Virtual Private Network (VPN) security.

Suggested Books:

1. W. Stallings, "Cryptography and Network Security", Third Edition, Prentice Hall International, 2013.
2. Jan C A, "Basic Methods of Cryptography", Cambridge University Press. 1998.
3. Thomas Calabrese, "Information Security Intelligence: Cryptographic Principles & Applications", Thomson Learning, 2003.
4. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2003.

CSE5306 Bio-Informatics

AI Algorithms For Bioinformatics: Sequence Alignment: Edit distance, LCS. PAM and BLOSUM Scoring Matrices. Global alignments. **Pattern Matching And Clustering**: Exact Pattern Matching: KMP Algorithm, Keyword Trees, Aho-Corasick Algorithm. Clustering Basics: Hierarchical Clustering, Multiple Sequence Alignment: CLUSTAL. **Bioinformatics – Techniques AndApplications**: Methods of sequence alignment. Pair wise alignment- Global, local, dot plot and its applications. Words method of alignment- FASTA. **Macromolecular Structure Analysis** : Gene prediction, Conserved domain analysis, Protein visualization, Prediction of protein secondary structure, Tertiary struct. **Numerical AndBiostatistical Methods**: Distributions – Binomial, Poisson and Normal, Handling Univariate, Bivariate and Multivariate data- Introduction to Probabilities, Interval Estimation.

Suggested Books:

1. N.C. Jones and P.A. Pevzner, "An Introduction to Bioinformatics Algorithms", MIT Press, 2005.
2. C. Gibas and P.Jambeck, "Developing Bioinformatics Computer Skills", O'Reilly Media,Inc., 2001.
3. S.S. Kremer, "Molecular Bioinformatics: Algorithms and Applications", Walter de Gruyter, 1996.
4. G.W. Collins, "Fundamental Numerical Methods and data analysis", George W. Collins, II Press, 2003.

CSE5306 Big Data Analytics

Introduction to Big Data: Evolution of Big data, Best Practices for Big data Analytics – Big data characteristics, Validating, The Promotion of the Value of Big Data, Big Data Use Cases- Characteristics of Big Data Applications, Perception and Quantification of Value, Understanding Big Data Storage, A General Overview of High-Performance Architecture, HDFS – MapReduce and YARN, Map Reduce Programming Model. **Clustering and Classification:** Advanced Analytical Theory and Methods: Overview of Clustering ,K-means, Use Cases – Overview of the Method, Determining the Number of Clusters, Diagnostics, Reasons to Choose and Cautions, Classification: Decision Trees Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Association and Recommendation System:** Advanced Analytical Theory and Methods-Association Rules, Overview – Apriori Algorithm, Evaluation of Candidate Rules, Applications of Association Rules, Finding Association& finding similarity, Recommendation System: Collaborative Recommendation-Content Based Recommendation, Knowledge Based Recommendation, Hybrid Recommendation Approaches. **Classification** :Classification: Decision Trees, Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms, Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Stream Memory:** Introduction to Streams Concepts, Stream Data Model and Architecture, Stream Computing, Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating moments, Counting oneness in a Window, Decaying Window, Real time Analytics Platform(RTAP) applications, Case Studies, Real Time Sentiment Analysis, Stock Market Predictions. Using Graph Analytics for Big Data: Graph Analytics. **NoSQL Data Management For Big Data And Visualization:** NoSQL Databases: Schema-less Models: Increasing Flexibility for Data Manipulation-Key Value Stores- Document Stores, Tabular Stores, Object Data Stores, Graph Databases Hive, Sharding, Hbase, Analyzing big data with twitter, Big data for E-Commerce Big data for blogs, Review of Basic Data Analytic Methods using R.

Suggested Books:

1. C. Eaton and D.deroos et al., "Understanding Big data ", McGraw Hill, 2012
2. A. Rajaraman and J.D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012
3. B. Iublinsky, K. t. Smith and A.Yakubovich, "Professional Hadoop Solutions", Wiley, ISBN: 9788126551071, 2015.
4. T. White, "HADOOP: The definitive Guide" , O Reilly 2012

CSE5314 Business Intelligence

Business Intelligence: Effective And Timely Decisions – Data, Information And Knowledge, Role Of Mathematical Models, Business Intelligence Architectures: Cycle Of A Business Intelligence Analysis – Enabling Factors In Business Intelligence Projects, Development of a Business Intelligence System – Ethics And Business Intelligence. **Knowledge Delivery:** The Business Intelligence User Types, Standard Reports, Interactive Analysis And Ad Hoc Querying, Parameterized Reports And Self-Service Reporting, Dimensional Analysis, Alerts/Notifications, Visualization: Charts, Graphs, Widgets, Scorecards And Dashboards, Geographic Visualization, Integrated Analytics, Considerations: Optimizing The Presentation For The Right Message. **Efficiency:** Efficiency Measures, The CCR Model: Definition Of Target Objectives, Peer Groups, Identification Of Good Operating Practices, Cross Efficiency Analysis, Virtual Inputs And Outputs, Other Models. Pattern Matching, Cluster Analysis, Outlier Analysis. **Business Intelligence Applications:** Marketing Models – McKinsey 7S model, The 7Ps of the Marketing Mix, AIDA, The Ansoff Matrix, The BCG Matrix, Diffusion of Innovation, DRIP Porter's Five Forces. Logistic And Production Models – Case Studies.**Future of Business Intelligence:** Future Of Business Intelligence, Emerging Technologies, Machine Learning, Predicting The Future, BI Search & Text Analytics, Advanced Visualization, Rich Report, Future Beyond Technology. **Future Of Business Intelligence:** Future Of Business Intelligence – Emerging Technologies, Machine Learning, Predicting The Future, BI Search & Text Analytics – Advanced Visualization – Rich Report, Future Beyond Technology.

Suggested Books:

1. E. Turban, R. Sharda and D.Delen, "Decision Support And Business Intelligence Systems", 9th Edition, Pearson 2013.
2. C.Vercellis, "Business Intelligence: Data Mining And Optimization For Decision Making", Wiley Publications, 2009.
3. C. Howson, "Successful Business Intelligence: Secrets To Making BI A Killer App", McGraw-Hill, 2007
4. L.T. Moss and S. Atre, "Business Intelligence Roadmap: The Complete Project Lifecycle Of Decision Making", Addison Wesley, 2003
5. R. Kimball , M. Ross, W. Thornthwaite, J. Mundy and B. Becker, "The Data Warehouse Lifecycle Toolkit", Wiley Publication Inc.,2007.

CSE5202 Optimization Tools

Introduction to Linear Programming: Prototype Example, the Linear Programming Model, Assumptions of Linear Programming, Additional Examples, Some Classic Case Studies. Graphical method, The Simplex Method: The Essence of the Simplex Method, Setting up the Simplex Method, The Algebra of the Simplex Method, The Simplex Method in Tabular Form, Tie Breaking in the Simplex Method,

Adapting to Other Model Forms, Post optimality Analysis. Duality Theory And Sensitivity Analysis: The Essence of Duality Theory, Economic. Interpretation of Duality, Primal-Dual relationships, Adapting to Other Primal Forms, The Role of Duality Theory in Sensitivity Analysis. Other Algorithms for Linear Programming:The Dual Simplex Method, Parametric Linear Programming, the Upper Bound Techniques, An Interior-Point Algorithm. Dynamic Programming: A prototype example for Dynamic Programming, Characteristics of Dynamic Programming Problems, Deterministic Dynamic Programming, Probabilistic Dynamic Programming. Integer Programming: Prototype Example, Some BIP Applications, Innovative Uses of Binary Variables in Model Formulation, Some Formulation examples, Some Perspectives on Solving Integer Programming Problems, The Branch-and-Bound Technique and Its application to Binary Integer Programming, A Branch-and-Bound Algorithm for Mixed Integer. Nonlinear Programming: Sample Applications, Graphical Illustration of Nonlinear Programming Problems, Types of Nonlinear Programming Problems, One-Variable Unconstrained Optimization, Multivariable Unconstrained Optimization, The Karush-Kuhn-Tucker (KKT) Conditions for Constrained Optimization, Quadratic Programming, Separable Programming , Convex Programming. Queuing Theory: Prototype Example, Basic Structure of queuing Models, Examples of Real Queuing Systems, The role of the Exponential Distribution, The Birth-and-Death Process, Queuing Models Based on the Birth-and Death Process, Queuing Models involving non exponential distributions

Suggested Books:

1. H.A.Taha, Operations Research, 8/e , Pearson Education, 2013.
2. J.K. Sharma, Operations Research, 3/e, Mcmillan , India Ltd, 2007
3. S. Hiller and G.J. Lieberman – Operations Research, 8th Edn, TMH, New Delhi, 2011.
4. K. Swarup, P.K. Gupta and M. Mohan, Operations Research, Sultan Chand & Sons, 2010.

CSE5204 Statistical Tools

Review of Probability and Distributions: Rules for probability, random variables and their distributions, moments, special discrete and continuous distributions, laws of large numbers and central limit theorem, sampling distributions. **Parametric Methods:** Point estimation – unbiasedness, consistency, UMVUE, sufficiency and completeness, method of moments, maximum likelihood estimation and method of scoring. Bayes, minimax and admissible estimators. Interval estimation - confidence intervals for means, variances and proportions. Testing of Hypotheses - tests for parameters of normal populations and for proportions, goodness of fit test and its applications. **Multivariate Analysis:** Multivariate normal, Wishart and Hotelling's T^2 distributions and their applications in testing of hypotheses problems. Classification of observations, principal component analysis, canonical correlations and canonical variables. **Nonparametric Methods:** Empirical distribution function, asymptotic distributions of order statistics, single sample problems, problems of location, prediction intervals,KolmogorovSmirnov one sample statistics, sign test, Wilcoxon signed rank statistics, two sample problems, Mann-Whitney-Wilcoxon tests, scale problems,KolmogorovSmirnov two sample criterion, Hoeffding's U-statistics

Suggested Books:

1. V.K. Rohatgi and A.K. Md.E.Saleh, An Introduction to Probability and Statistics, Wiley,2008.
2. E.J. Dudewicz and S.N. Mishra, Modern Mathematical Statistics, wiley, 1988.
3. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 2009.

4. T. W. Anderson, An Introduction to Multivariate Analysis, 2009.

5. J.D. Gibbons and S. Chakraborti, Nonparametric Statistical Inference, Chapman and Hall, 2010.

CSE5206 Geo-Informatics

Fundamentals Of Gis Introduction to GIS ;Basic spatial concepts ;Coordinate Systems; GIS and Information Systems History of GIS ;Components of a GIS: Hardware, Software, Data, People and Methods; Proprietary and open source Software; Types of data: Spatial, Attribute data; types of attributes ; scales/ levels of measurements. **Spatial Data Models** Database Structures: Relational, Object Oriented ; Entities; ER diagram ; data models: conceptual, logical and physical models; spatial data models ; Raster Data Structures ; Raster Data Compression; Vector Data Structures;Raster vs Vector Models; TIN and GRID data models. **Data Acquisition** Acquisition and storage of Numeric data,Textual data , image data , Audio data ,Animation and Video data ;Data formats; fundamentals of image and video compression ; introduction to geospatial data; remote sensing sensors, data organization. **Data Quality And Standards** Data quality ; Basic aspects - completeness, logical consistency, positional accuracy, temporal accuracy, thematic accuracy and lineage ; Metadata; GIS Standards; Interoperability; OGC; Spatial Data Infrastructure. **Data Management And Output** Import / Export; Data Management functions; Raster to Vector and Vector to Raster Conversion; Data Output; Map Compilation; Chart/Graphs; Enterprise Vs. Desktop GIS; Distributed GIS. **Geoinformation**Information System ;GIS ;GPS ;Information retrieval system ; Geo-database ; interactive applications ; Multimedia applications ; Earth resource platform ; Google maps and Google earth ; LBS; Introduction to Integration of Geo-database and Social networking applications.

Suggested Books:

1. K.T. Chang, " Introduction to Geographic Information Systems", 2nd Edition, McGraw Hill Publishing, 2011.

2. I. Heywood, S. Cornelius, S. Carver and S. Raju, "An Introduction Geographical Information Systems, 2nd Edition, Pearson Education, 2007

3. Lo Albert C.P. Yeung K.W. Concepts and Techniques of Geographic Information Systems, Prentice Hall of India Publishers, 2006.

CSE5208 Security Tools and Applications

Network Security tool taxonomy:Reconnaissance tools, attack and penetration tools, defensive tools.High, Medium, Low and Virtual honeypots, NMAP, TCPDUMP, Wireshark, Reverse firewalling, securing honeypots, sebek, Argos, Honeywall.Hybrid systems, client honeypots, Botnets, tracking botnets, analysing malware.Capturing malware using honeypots, implementing honeypots, medium interaction and high interaction honeypots.Security metrics: What is a security metric? Metric and measurement, Designing effective security metrics, Data sources for security metrics, Analysis of security metrics data, Designing the security measurement project, Measuring security cost and value, Different context for security process management.

Suggested Books:

1. G.M. Jackson, Predicting Malicious Behavior, John Wiley & Sons, 2012.

2. N. Provos and Thorsten Holz, Virtual Honeypots: From Botnet Tracking to Intrusion Detection, Addison Wesley, 2007.

3. L. Hayden, IT Security Metrics, Tata McGraw Hill, 2010.

4. L.Spitzner, Know Your Enemy: Learning about Security Threats (2nd Edition), 2004.

5. M. Schiffman, Building Open Source Network Security Tools: Components and Techniques, Wiley, 2002.

CSE5214 Advances in Multimedia Technology

Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Outline Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. **Audio and Speech** Data Acquisition, Sampling and Quantization, Human Speech Production Mechanism, Digital Model of Speech Production, Analysis and Synthesis, Psycho-Acoustics, Low Bit Rate Speech Compression, MPEG Audio Compression. Compression and Transmission of Audio on Internet, Adding Sound to your Multimedia Project, Audio Software and Hardware. **Images and Video** Colour Science, Colour, Colour Models, Colour palettes, Dithering, 2D Graphics, Image Compression and File Formats: GIF, JPEG, JPEG 2000, PNG, TIFF, EXIF, PS, PDF, Basic Image Processing [Can Use Photoshop], Image acquisition and representation, composite video signal, NTSC, PAL and SECAM video standards. Video compression based on motion compensation, MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21. **Multimedia and Hypermedia** Communication: Fundamentals of Data Communication and Networking, Bandwidth Requirements of Different Media; Real Time Constraints: Audio Latency, Video Data Rate; Multimedia over LAN and WAN, Multimedia Conferencing. Hypermedia Presentation: Authoring and Publishing, Linear and Nonlinear Presentation, Structuring Information, Different Approaches of Authoring Hypermedia Documents, Hypermedia Data Models and Standards. Data Models for Multimedia and Hypermedia information.

Suggested Books:

1. T. Vaughan's "Multimedia: Making it work", Tata McGraw-Hill, 2017

2. R. Aggarwal and B.B Tiwari, "Multimedia Systems", Excel Publication, New Delhi, 2007.

3. Li and Drew, "Fundamentals of Multimedia", Pearson Education, 2009.

4. D. Hillman, "Multimedia Technology and Application", Galgotia Publication, 1998.

SEMESTER III

CSE651 Research Project

CSE601 Major Project I

CSE6401 Pattern Recognition

Introduction to Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Random Vectors, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations. Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient Statistics, Coping with Missing or Noisy Features. Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent. Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation, Parzen Estimation. Unsupervised Learning, Clustering, Vector Quantization, K-means, Mixture Modelling, Expectation-Maximization. Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks.

Suggested Books:

1. R. O. Duda, P. Hart, D. Stork, Pattern Classification, 2nd Ed. Wiley, 2000.
2. C.M. Bishop, Pattern Recognition and Machine Learning. Springer, 2007.
3. C.M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.
4. S. Theodoridisand K. Koutroumbas, Pattern Recognition, 4th Ed. Academic Press, 2008.
5. T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning, Springer, 2009.

CSE6403 Software Project Management

Introduction: Project Management concepts, Process Framework, Project Planning Software Life Cycle Models, Artifacts of the Project Management Process. **Cost and Scheduling Estimation Models**: Various Levels of COCOMO for Cost, Effort, Schedule and Productivity Estimation. Approaches to Effort, Cost Estimation, and Schedule Estimation factors through COCOMO II, Putnam Estimation Model, Algorithmic models. **Project Management Techniques**: Project Organizations and Responsibilities, Establishing Project Environment, Risk Management Process, Project Tracking and Control Defect Tracking Concepts such as Process monitoring and audit, Reviews, Inspections and Walkthroughs. **Project Closure**: Project Closure Analysis, Role of Closure Analysis in a project, Performing Closure Analysis, Closure Analysis Report. **Software Project Management Renaissance**: Conventional Software Management, Evolution of Software Economics, Improving Software Economics, The old way and the new way. **Advance Topics in Software Project Management**: Discussion on future Software Project Management Practices & Modern Project Profiles, Next Generation Software Economics, Modern Process Transitions.

Suggested Books:

1. W.S. Humphrey, "Managing the Software Process", Pearson Education, 1989.
2. W. Royce, "Software Project Management", Pearson Education.1998.
3. P. Jalote, "Software Project Management in Practice", Pearson Education, 2002.
4. B. Hughes, "Software Project Management", TMH, 1968.
5. C.F.Kemerer, "Software Project Management Readings and Cases", TMH, 7996.

CSE6405 Cluster & Grid Computing

Introduction: Cluster and Grid computing, Meta-computing, Web services and Grid Computing, e-Governance and the Grid

Technologies and Architectures for Grid Computing: Issues in Data Grids, Functional requirements in Grid Computing, Standards for Grid Computing, Recent technologies trends in Large Data Grids. **Web Services and the Service Oriented Architecture**: Service Oriented Architecture, SOAP and WSDL, Creating Web Services, Server Side. **OGSA and WSRF**: OGSA for Resource Distribution, Stateful Web Services in OGSA, WSRF, WSRF Specification. **Globus Toolkit**: History, version, Applications, Approaches and Benefits, Infrastructure Management, Monitoring and Discovery, Security, Data Choreography and Coordination, GT4 Architecture, GT4 Containers. **The Grid and Databases**: Requirements, Storage Request Broker, Integration of Databases with the Grid, Architecture of OGSA-DAI for offering Grid Database services. **Cluster Computing**: Approaches to Parallel Computing, Definition and Architecture of a Cluster, Categories of clusters. **Cluster**

Middleware: Levels and Layers of Single System Image, Design objectives, Resource Management and Scheduling, Cluster programming Environment and Tools. **Networking, Protocols and I/O for clusters**: Networking and Interconnection/Switching Devices, Design Issues, Design Architecture, HiPPI, ATM, Myrinet, Memory Channel. **Setting Up and Administering a Cluster**: Setup of simple cluster, setting up nodes, clusters of clusters, System monitoring, Global Clocks Sync. **Cluster Technology for High Availability**: High availability clusters, high availability parallel computing, types of failures and errors, cluster architectures and configurations for high availability, Failure/ Recovery clusters. **Process Scheduling**: Job management System, Resource management system, policies of resource utilization, Scheduling policies. **Load Sharing and Load Balancing**: Introduction, Strategies for load balancing, Modelling parameters.

Suggested Books:

1. W. Gropp, E. Lusk and T. Sterling, Beowulf Cluster Computing with Linux, 2nd edition, MIT Press,2003.
2. B. Jacob and M. Brown, Introduction to grid computing, Vervante, 2005.
3. G.F. Pfister, In Search of Clusters: The ongoing battle in lowly parallel computing, Second Edition, Prentice Hall Publishing Company, 1998.
4. C.S.R. Prabhu, Grid and Cluster Computing, PHI,2008
5. R. Buyya, High Performance Cluster Computing: Architectures and Systems, Volume 1, Pearson Education,2008.
6. D. Janakiram, Grid Computing, Tata McGraw-Hill,2005.

CSE6407 Internet of Things

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs IoTenabaled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle. **IoT and M2M:** Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER. **Introduction to Python:** Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling Python packages – JSON, XML, HTTPLib, URLLib, SMTPLib. **IoT Physical Devices and Endpoints:** Introduction to Raspberry PI-Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, and reading input from pins. **IoT Physical Servers and Cloud Offerings:** Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework designing a RESTful web API.

Suggested Books:

1. A. Bahga and V. Madisetti, Internet of Things – A Hands-on Approach, Universities Press, 2015.
2. M. Richardson and S. Wallace, Getting Started with Raspberry Pi, O'Reilly (SPD), 2014.
3. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos and D. Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.

4. B.S. Reiter and F.Michahelles, "Architecting the Internet of Things", Springer, 2011.

5. W. Stallings, "Foundations of modern networking: SDN, NFV, QOE, IOT, and cloud" publisher: Addison-Wesley 2015

CSE6409 Nanotechnology

Introduction to nanoscale systems. Length, energy, and time scales. Top-down approach to nanolithography. Spatial resolution of optical, deep-ultraviolet, x-ray, electron beam, and ion beam lithography. Single electron transistors, coulomb blockade effects in ultra-small metallic tunnel junctions. Quantum confinement of electrons in semiconductor nanostructures: two-dimensional confinement (quantum wells). Band gap engineering. Epitaxy. Landauer-Buttiker formalism for conduction in confined geometries. One-dimensional confinement: quantum point contacts, quantum dots. Bottom-up approach. Chemical self-assembly, carbon nanotubes. Molecular electronics. Self-assembled monolayers. Electrochemical techniques; applications in biological and chemical detection. Atomic scale characterization techniques: scanning tunneling microscopy, atomic force microscopy. Introduction to quantum methods of information processing.

Suggested Books:

1. D. Ferry, Transport in Nanostructures, Cambridge University Press, 2000.

2. Y. Imry, Introduction to Mesoscopic Physics, Oxford University Press, 1997.

3. S.Datta, Electron Transport in Mesoscopic Systems, Cambridge University Press, 1995.

4. H. Grabert and M. Devoret, Single Charge Tunneling, Plenum Press, 1992.

5. Beenaker and V. Houten, Quantum Transport in Semiconductor Nanostructures, in Solid State Physics v. 44, eds. Ehernreich and Turnbull, Academic Press, 1991.

6. P.R. Choudhury, Handbook of Microlithography, Micromachining & Microfabrication, SPIE, 1997.

CSE6301 Natural Language Processing

Introduction- Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. **Words and Word Forms** : Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Morphology, acquisition models, Finite State Transducer. N-grams, smoothing, entropy, HMM, ME, SVM, CRF. **Structures** : Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution. **Meaning** : Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences. **Web 2.0 Applications** : Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Suggested Books:

1. D. Jurafsky and J.H. Martin, Speech and Language Processing, 2e, Pearson Education, 2009.

2. A. James, Natural language Understanding 2e, Pearson Education, 1994 .

3. A. Bharati, R. Sangal, V. Chaitanya, Natural language processing: a Paninian perspective, PHI, 2000.

CSE6303 Digital Forensics

C Computer Forensics Fundamentals: What is Computer Forensics, Use of Computer Forensics in Law Enforcement, Computer Forensics Assistance to Human Resources, Computer Forensics Services, Benefits of Professional Forensics Methodology. Computer Forensics Technology- Military Computer Forensic Technology, Law Enforcement, Computer Forensic Technology, Business Computer Forensic Technology. **Computer Forensics Evidence and Capture:** Data Recovery Defined, Data Back-up and Recovery, The Role of Back-up in Data Recovery, The Data-Recovery Solution. Evidence Collection and Data Seizure -Collect Evidence, Collection Options, Obstacles, Evidence, The Rules of Evidence, Volatile Evidence, General Procedure, Collection and Archiving, Methods of Collection, Artifacts, Collection Steps, Controlling Contamination: The Chain of Custody. **Duplication and Preservation of Digital Evidence:** Preserving the Digital Crime Scene, Computer Evidence Processing Steps, Legal Aspects of Collecting and Preserving Computer Forensic Evidence. Computer Image Verification and Authentication - Special Needs of Evidential Authentication, Practical Consideration, Practical Implementation. **Computer Forensics analysis and validation:** Data collection and analyzing, validating forensic data, addressing data-hiding techniques, performing remote acquisitions. Network Forensics - performing live acquisitions, developing standard procedures for network forensics. Processing Crime and Incident Scenes - digital evidence, collecting evidence in private-sector incident scenes, processing law enforcement crime scenes, seizing digital evidence at the scene, storing digital evidence, obtaining a digital hash. **Working with Windows and DOS Systems:** Understanding file systems, exploring Microsoft File Structures, NTFS disks, Understanding whole disk encryption, windows registry, Microsoft startup tasks, MS-DOS startup tasks, virtual machines. **Current research trends and Forensic tools:** Research trend in digital forensics- Digital forensics tools, network analysis, computer forensics, cloud forensics. Evaluating computer forensic software and hardware tools, validating and testing forensics software.

Suggested Books:

1. B. Nelson, A. Phillips, C. Steuart, Computer Forensics and Investigations,CENGAGE Learning, 2015.

CSE6305 Game Theory

Introduction to Game Theory: What is game theory. Theory of rational choice, Interacting decision makers. **Strategic Games and Nash Equilibrium:** Strategic games: examples, Nash equilibrium: concept and examples, Best response functions, Dominated Actions, Symmetric games and symmetric equilibria. **Illustrations of Nash Equilibrium and Extensive Games:** Cournot's model of duopoly market, Bertrand's model of duopoly market, Electoral Competition, War of Attrition, Auctions, Accident Laws. Stackelberg model of duopoly markets, Ultimatum game.**Mixed Strategy Nash Equilibrium:** Introduction, Strategic games with randomisation, Mixed strategy Nash equilibrium: concept and examples, Dominated Actions, Formation of Players' beliefs.**Extensive Games and Nash Equilibrium:** Introduction to extensive games, Strategies and outcomes, Nash equilibrium, Subgame perfect Nash equilibrium, Backward induction. **Research Trends in Game Theory:** Research trends include dynamic games, games of incomplete information, and evolutionary games, applications in the fields of voting, bargaining, lobbying and violent conflict

Suggested Books:

1. Nisan, Roughgarden, Tardos, Vazirani, Algorithmic Game Theory, Cambridge University Press, 2007
2. M. Osborne, An Introduction to Game Theory, Oxford University Press, 2003
3. A. MacKenzie, Game Theory for Wireless Engineers, Synthesis lectures on Communications, 2006
4. R. Gibbons, A Primer in Game Theory, Pearson Education, 1992

CSE6307 Deep Learning

Introduction: Introduction to K-Nearest Neighbors, Deep Feedforward Networks, Regularization of deep learning, Optimization for training deep models, convolutional networks, recurrent networks, Applications. **Convolutional Neural Networks:** Invariance, stability Properties of CNN representations: invertibility, stability, invariance. Variantsof the Basic Convolution Function ,history of CNN and deep learning **Recurrent and Recursive Nets:** Recurrent and Recursive Nets, Unfolding Computational Graphs, Recurrent Neural Network, Bidirectional RNNs, Deep Recurrent Networks , Recursive Neural Networks , The Challenge of Long-Term Dependencies , Echo State Networks, Leaky Units and Other Strategies for Multiple, Time Scales , The Long Short-Term Memory and Other Gated RNNs, optimization for Long-Term Dependencies, Explicit Memory. **Linear Factor Model and Autoencoder:** Linear Factor Models ,Probabilistic PCA and Factor Analysis Independent Component Analysis (ICA) ,Slow Feature Analysis, Sparse Coding, Autoencoders ,UndercompleteAutoencoders ,Regularized Autoencoders, Stochastic Encoders and Decoders , Applications of Autoencoders. **Deep Supervised Learning:** Introduction to Deep Supervised Learning, Convolution & Pooling, Dropout, Transfer Learning Transfer Learning Scenarios, Applications of Transfer Learning, transfer Learning Methods, Fine Tuning and Data Augmentation, Related Research Areas. **Review of Other Neural Networks**: Introduction other Deep Neural Networks , Recursive Neural Networks, Boltzmann and Restricted Boltzmann Machine , Case Studies :Various Frameworks such as DIGITS, Tensorflow, Caffe and Theano

Suggested Books:

1. I. Goodfellow, Y. Bengio and A.Courville, Deep Learning, MIT Press, 2015.
2. A. Gibson and J Patterson, Deep Learning, O'Reilly Media, Inc., 2017.
3. S.J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach. Prentice Hall, 1994.
4. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification, Wiley, 1973.
5. C. M. Bishop, Neural Networks for Pattern Recognition. Oxford University Press, **1995.**

CSE6309 Blockchain and Applications

Need for Distributed Record Keeping, Modeling faults and adversaries Byzantine Generals problem,Consensus algorithms and their scalability problems. Why Nakamoto Came up with Blockchain based cryptocurrency? Technologies Borrowed in Blockchain – hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash etc. Atomic Broadcast, Consensus, Byzantine Models of fault tolerance. Hash functions, Puzzle friendly Hash, Collison resistant hash, digital signatures, public key crypto, verifiable random functions, Zero-knowledge system. Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their use. Ethereum and Smart Contracts, The Turing

Completeness of Smart Contract Languages and verification challenges, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts. Hyperledger fabric, the plug and play platform and mechanisms in permissioned blockchain, pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains such as Sybil attacks, selfish mining, 51% attacks - -advent of algorand, and Sharding based consensus algorithms to prevent these.

Suggested Books:

1. M. Swan, "Blockchain: Blueprint for a New Economy", O'Reilly Media, 2015.
2. J. Thompsons,Blockchain: The blockchain for beginners guide to blockchain technology and leveraging blockchain programming", 2017

CSE6311 Real Time Systems

Real-time systems: Real-time systems models, Types of real-time systems, Internal structure of real-time systems, Performance measures, Examples of real-time systems and real-world applications, Modeling& Designing real-time systems. **Real-Time Process Management:** Task scheduling for Uniprocessor systems, handling priorities with critical section, interrupts, task allocation & scheduling for multiprocessor systems, adaptive scheduling. **Programming Environment:** In depth Knowledge of RTOS programming languages, tools & techniques. **Real-Time System Design:** Design techniques for Reliability, Fault Tolerance & other application specific quality considerations. **Trends in Real-Time System** Design & Development in fields such as Robotics. **Case Studies of RTOS:** RT Linux, Micro C/OS-II, Vx Works, Embedded Linux, and Tiny OS

Suggested Books:

1. A.C. Shaw, Real-Time Systems and Software, Wiley, 2001.
2. J.E. Cooling, Real-Time Software Systems, International Thompson Computer Press, 1997.
3. W.A. Halang and K.M. Sacha, Real-Time Systems, World Scientific, 1992.
4. P.H. Laplante, Real-Time Systems Design and Analysis, IEEE Press.1992.
5. J. Liu, Real-Time Systems, Prentice-Hall, 2000.
6. S. Bennett, Real-Time Computer Control, Prentice-Hall, 1984.
7. C.M. Krishna and K.G. Shin, Real-Time Systems, McGraw-Hill, 1997.

CSE6313 Quantum Computing

Introduction to Quantum Computers: Qubits & their representation, multiple qubits, Bloch sphere representation of a qubit. **Quantum Elements:** Logic Gates, Circuits, Architectures, design of quantum circuits. **Quantum Information and Cryptography** : Quantum Key Distribution, teleportation, Single photons, EPR pairs, Bell states. Quantum Cryptography, no cloning theorem. **Quantum Algorithms:** Introduction to quantum algorithms,Deutsch's algorithm, Deutsch's-Jozsa algorithm, Shor factorization, Grover search. **Error correction:** Graph states and codes, Quantum error correction, fault-tolerant computation. **Implementations:** Different implementations of quantum computers. NMR and ensemble quantum computing, Ion trap implementations. Optical implementations.

Suggested Books:

1. P. Kaye etal., Introduction to Quantum Computing, Oxford University Press, 2006.
2. G.P. Berman, Introduction to Quantum Computers, World Scientific, 1998.
3. M. Nielsen and I. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, Cambridge, 2000.
4. A. Yu. Kitaev, A.H. Shen, and M.N. Vyalyi, Classical and Quantum Computation,American Mathematical Society, Providence, 2002.
5. W.H. Steeb and Y. Hardy, Problems & Solutions in Quantum Computing & Information, World Scientific, River Edge, NJ, 2004.

CSE6201 Research Methodology

Foundation of Research and Problem Definition Meaning, Objective and Importance of research, Types of research, steps involved in research, identification of research problem and its formulation. **Research Design** Research design, Methods of research design, research process and steps involved, Literature Survey. **Data Collection and Analysis** Classification of Data, Methods of Data Collection, Sampling techniques, Ethical considerations in research. Data analysis, Statistical techniques, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), Interpretation of results. **Reporting of Research** Types of research report, Referencing and referencing styles, Indexing and citation of Journals, Reference management software like Mendeley, Intellectual property, Plagiarism.

Suggested Books:

1. C. R. Kothari and G. Garg, Research Methodology Methods and Techniques, New Age International publishers, Third Edition, 2019
2. Donald Cooper and Pamela Schindler, Business Research Methods, TMGH, 9th edition, 2013
3. Creswell and W. John, Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications, 2013

CSE6203 Enterprise Computing in JAVA

Introduction to J2EE and building J2EE applications, MVC architecture, Introduction to servlets and its life cycle , problems with cgi-perl interface , generic and http servlet , servlet configuration, various session tracking techniques, servlet context, servlet configuration, servlet collaboration. **JSP Basics and Architecture**: JSP directives, Scripting elements, standard actions, implicit objects, JSP design strategies. **Struts**: Introduction of Struts and its architecture, advantages and application of Struts.

EJB Fundamentals: Motivation for EJB, EJB Echo system, J2EE technologies, Enterprise beans and types, distributed objects and middleware, developing EJB components, remote local and home interface, bean class and deployment descriptor. **Introducing session beans**: Session beans life time, statefull and Stateless session beans, lifecycle of session beans.

Introducing Entity beans: Persistence concepts, features of entity beans, entity context. Introduction to JMS & Message driven beans. Web-enabled EJBs with JAX-RS, Web-UI integration, EP Drop/ Audit Deadline , EJB/JavaEE Security, JavaEE Interceptors, JMS, Asynchronous Methods, EJB Timers.

Suggested Books:

1. E.D. Roman, S.W. Ambler and T. Jewell, "Mastering Enterprise Java Beans", Wiley, 2nd Ed., 2005.
2. G.Sesadri , "Enterprise Java Computing: Application and Architectures", Cambridge University Publications, 1999.
3. T.Neward, "Effective Enterprise Java", Eddison -Wesley, 2004.
4. J. Farley and W. Crawford, " Java Enterprise in a Nutshell", O'Reilly and Associates, 2005.
5. A. Sincock , "Enterprise Java for SAP" , A Press Publications, 2003.
6. J. Wigglesworth and M. Paula, "Java Programming: Advanced Topic", Thomson, 3rd Ed., 2003.
7. S. Allamaraju and C.Buest, "Professional Java Server Programming, J2EE, Apress, 1.3 Ed., 2005.
8. I. Bayross and S. Shah, "Java Server Programming", Shroff, 2008.

CSE6205 Advances in Internet & Web Technology

Internet Computing: Internet: The Giant WAN; Communicating over the Internet (Protocol Layering, Internet Addressing); Accessing the Internet (Internet Configuration, Web Browser); Internet Organizations; Cyber Ethics; Internet Services (Electronic Mail, File Transfer, Real-time User Communication , Remote Login, Usenet, World Wide Web. **Web Theory:**

The World Wide Web; The Working of Web; Web Terminology (Web page, Website, Web Apps, Web Service); Web Architecture; World Wide Web Challenges; Hypertext Transfer Protocol (HTTP); HTTP Version; HTTP Connections (Non-Persistent HTTP, Persistent HTTP); HTTP Communication (Handshaking ; Request Message; Response Message); Hypertext Transfer Protocol Secure (HTTPS); HTTP State Retention: Cookies; HTTP Cache (Cache Consistency); Evolution of Web (Web 1.0, Web 2.0, Web 3.0); Web Information Retrieval (Web IR); Web IR Tool; Web IR Architecture (Search Engine Architecture); Web IR Performance Metrics. **Web Development:** Elements of Web Development; Client Side and Server-side scripting; Model-View-Controller (MVC) Architecture; Client-side Technologies(HTML, CSS, JavaScript); Server-side Technologies (PHP); Web Databases. **Web Research:** Research Trends in Web; Contextual Information Retrieval; Web Mining; Social media analytics, Sentiment Analysis, Recommender systems.

Suggested Books:

1. Web Technology: Theory and Practice by Akshi Kumar, CRC Press, Taylor and Francis Group, A Chapman & Hall Book, 2018.
2. Internet and Web Technologies by Raj Kamal, Tata McGraw Hill edition, 2017.
3. Web Technologies by Uttam K. Roy, Oxford University Press, 2010.
4. HTML: A Beginner's Guide by Wendy Willard, Tata McGraw-Hill, 2013.
5. R.W. Sebesta, Programming World Wide Web, Pearson, 2001
6. The World Wide Web Consortium: w3c.org

SEMESTER IV

CSE652 Research Project

CSE602 Major Project II

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Software Engineering)

Programme Specific Outcomes

1. Apply the knowledge of computer science and software engineering to provide solutions to real world problems.
2. Apply appropriate techniques, use modern tools and packages for quality software development by through understanding of requirements under given constraints.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN SOFTWARE ENGINEERING (SWE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	SWE501	Software Requirement Engineering	Core	4	3	0	2	15	25	20	40	-	17
	2	SWE503	Object Oriented Software Engineering	Core	4	3	0	2	15	25	20	40	-	
Group B	3	SWE5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	SWE5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	SWE5201/5203/...../ UEC5201/5203/.....	Elective 3	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	SWE502	Software Testing	Core	4	3	0	2	15	25	20	40	-	17
	2	SWE504	Empirical Software Engineering	Core	4	3	0	2	15	25	20	40	-	
Group D	3	SWE5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	SWE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	0	30	50-	-	
	5	SWE5202/5204/...../ UEC5202/5204/.....	Elective 6	Elective	2	2	0	0	20	0	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	`ETE	PRE	Total Credits
	Track 1													
Group E	1	SWE651	Research Project	Core	12	0	0	12	0	0	-	100	-	12
	Track 2													
	1	SWE601	Major Project I	Core	3				0	0	40	60	-	12
	2	SWE6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	SWE6301/6303/.....	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	SWE6201/6203/.....	Elective 9	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/ 60	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	`ETE	PRE	Total Credits
	Track 1													
Group F	1	SWE652	Research Project	Core	12	0	0	12	0	0	-	100	-	12
	Track 2													
	1	SWE602	Major Project II	Core	12	0	0	12	0	0	0	100	-	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	SWE5401	Advanced Database Management Systems	Elective	4	3	0	2	15	25	20	40	-
	2	SWE5403	Programming Languages		4	3	0	2	15	25	20	40	-
	3	SWE5405	Advanced Operating System		4	3	0	2	15	25	20	40	-
	4	SWE5407	Advanced Data Structures		4	3	0	2	15	25	20	40	-
	5	SWE5409	Data Warehousing Data Mining		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	SWE5301	Project Work	Elective	3	0	0	-	-	40	-	-	60
	2	SWE5303	Artificial Intelligence		3	3	0	0	20	-	30	50	-
	3	SWE5305	Information Retrieval		3	3	0	0	20	-	30	50	-
	4	SWE5307	Fuzzy Logic and Neural Networks		3	3	0	0	20	-	30	50	-
	5	SWE5309	Software Project Management		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	SWE5201	SEMINAR	Elective	2	2	0	0	0	-	0	100	-
	2	SWE5203	Probability and Statistics		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	SWE5402	Software Design Patterns	Elective	4	3	0	2	15	25	20	40	-
	2	SWE5404	Soft Computing		4	3	0	2	15	25	20	40	-
	3	SWE5406	Machine Learning		4	3	0	2	15	25	20	40	-
	4	SWE5408	Big Data Analytics		4	3	0	2	15	25	20	40	-
	5	SWE5410	Wireless and Mobile Computing		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	SWE5302	MINOR PROJECT	Elective	3	0	0	-	-	40	-	-	60
	2	SWE5304	Optimization Techniques		3	3	0	0	20	-	30	50	-
	3	SWE5306	Pattern Recognition		3	3	0	0	20	-	30	50	-
	4	SWE5308	Distributed Systems		3	3	0	0	20	-	30	50	-
	5	SWE5310	Natural Language Processing		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	SWE5202	Research Methodology	Elective	2	2	0	0	20	-	30	50	-
	2	SWE5204	Predictive Modelling		2	2	0	0	20	-	30	50	-
	3	SWE5206	Operational Research		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	SWE6401	Advances in Software Engineering	Elective	4	3	0	2	15	25	20	40	-
	2	SWE6403	Cloud Computing		4	3	0	2	15	25	20	40	-
	3	SWE6405	Things of the Internet		4	3	0	2	15	25	20	40	-
	4	SWE6407	Multimedia Applications		4	3	0	2	15	25	20	40	-
	5	SWE6409	Information Theory and Coding		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	SWE6301	Agile Methods	Elective	3	3	0	0	20	-	30	50	-
	2	SWE6303	Software Reliability		3	3	0	0	20	-	30	50	-
	3	SWE6305	Cluster and Grid Computing		3	3	0	0	20	-	30	50	-
	4	SWE6307	Software Quality & Metrics		3	3	0	0	20	-	30	50	-
	5	SWE6309	Swarm and Evolutionary Computing		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	SWE6201	Data Security & Privacy	Elective	2	2	0	0	20	-	30	50	-
	3	SWE6203	Bio Informatics		2	2	0	0	20	-	30	50	-
	5	SWE6205	Statistical Tools		2	0	0	4	-	40	-	-	60

SEMESTER I

Courses

SWE501 Software Requirement Engineering

The primary objective of the course is to understand the software requirements, how to effectively collect them and to learn the corresponding tools that aid in requirements engineering. The topics include essential of software requirements, different dimensions and good practices for requirements engineering, improving requirements processes, and risk management. It also incorporates review of various activities of requirements engineering and discussion on current trends. Principles and practices of software requirements management, requirements attributes, change management process, requirements traceability matrix, links in requirements chain are also included. RM Tools, implementing requirements management automation and current trends such as aspect-oriented requirement engineering and agent-based requirement engineering are a part of the course structure.

Suggested Books:

1. R. Naik and S. Kishore, "Software Requirements and Estimation", Tata McGraw Hill, 2007.
2. K. E. Weigers, "Software Requirements" Microsoft Press, 1999.
3. E. Gottesdiener, "Requirements by Collaboration: Workshops for Defining Needs", Addison Wesley, 2002.

SWE503 Object-Oriented Software Engineering

The goal of this course is to make one design, assess and analyze object-oriented philosophy at each phase of software development life cycle. Basic concepts: Software engineering, object-orientation, object-oriented methodologies and modelling. Software development life cycles, object-oriented software life cycle models, software requirements elicitation and analysis, use case approach. Object-oriented Software Estimation: Need, Lorenz & Kidd estimation, use case points method, class point method, object-oriented function point, risk management. Object-oriented analysis, Object-Oriented design, Software testing.

Suggested Books:

1. Y. Singh, R. Malhotra, "Object-Oriented Software Engineering", PHI Learning, 2012.
2. I. Jacobson, "Object Oriented Software Engineering: A Use-case Driven Approach", Pearson Education, 2009.
3. R. Laganiere & T.C. Letbridge, "Object-oriented Software Engineering: Practical Software Development Using UML and Java", Tata McGraw Hill, 2004.

SWE5401 Advanced Database Management

This course covers topics of Relational Databases Integrity Constraints, Extended ER diagram, Relational Algebra & Calculus, Functional, Muiltivalued and Join Dependency, Normal Forms, Rules about functional dependencies. Advanced Transaction Processing, Query Processing, Query Optimization: Indexing and Query Optimization, Parallel and Distributed Databases: Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Active Database and Real Time Databases: Triggers in SQL, Event Constraint and Action.

Suggested Books:

1. R. Elmasri, S..B. Navathe, "Fundamentals of Database Systems", Sixth Edition, Pearson Education, 2017.
2. Garcia-Molina, "Database Systems, The complete book", Pearson, 2014.
3. A. Silberschatz, H. F. Korth, S. Sudarshan, "Database System Concepts", Sixth Edition, Mcgraw Hill, 2013.
4. C.J. Date, A. Kannan, S. Swaminathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2007.

SWE5403 Programming Languages

The objective of the course is to introduce programming fundamentals through Python language. Planning the Computer Program, Techniques of Problem Solving, Overview of Programming: Structure of python program, basic elements of python program. Introduction to Python: Python Interpreter, Using Python as calculator, Python shell, Indentation. Atoms, Identifiers and keywords, Literals, Strings, Operators. Creating Python Programs: Input and Output Statements, Control statements, Defining Functions, default arguments, Errors and Exceptions. Iteration and Recursion, Strings and Lists, Object Oriented Programming: Introduction to Classes, Objects and Methods, Standard Libraries. Data Structures: Arrays, list, set, stacks and queues. Searching and Sorting.

Suggested Books:

1. T. Budd, "Exploring Python", First Edition, Tata McGraw Hill, 2011.
2. A. Downey, J. Elkner, C. Meyers. "How to think like a computer scientist learning with Python", First Edition, Freely Available Online, 2012.

SWE5405 Advanced Operating System

The objective of the course is to learn various concepts related to operating systems. Operating system concepts: history, evolution and philosophy of operating systems. Concurrent processes, process coordination and synchronization, CPU scheduling, deadlocks, memory management, virtual memory, secondary storage and file management, device management, security and protection, networking, and distributed and real-time systems.

Suggested Books:

1. A Silberschatz, P.B. Galvin, G. Gagne, "Operating Systems Concepts", Eighth Edition, John Wiley Publications, 2008.
2. A.S. Tanenbaum, "Modern Operating Systems", Third Edition, Pearson Education, 2007.
3. W. Stallings, "Operating Systems, Internals & Design Principles", Fifth Edition, Prentice Hall of India, 2008.

SWE5407 Advanced Data Structures

This course covers topics of Review of Elementary data structures, Sparse matrices, Advanced Data Structures: data structures for combinatorial, Operations on Disjoint Divide and Conquer approach, Graph Algorithms: Definitions and Algorithms, Greedy Method and Dynamic Programming, Dynamic Programming, Advanced Algorithms: NP Complete problems, Approximation algorithms for NP complete problem, Algorithms for matching, Flow and circular problems, Bio Inspired Algorithm-

Genetic Algorithm, Particle Swam, Artificial Bee Colony, Firefly Algorithm, Bat Algorithm.

Suggested Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, "Introduction to Algorithms", MIT Press, 2009.
2. R.E. Tarjan, "Data Structures and Network algorithms", SIAM Regional Conference series in Applied Mathematics, 1987.
3. Aho, Hopcraft & Ulman, "The Design and Analysis of Computer algorithms", Addison Wesley, 1974.
4. S. Dasgupta, C. H. Papadimitriou, and U.V.V Azirani, "Algorithms", Tata McGraw Hill, 2017.
5. Y. Langsam, M. J. Augenstein, A. M. Tenenbaum, "Data Structures using C and C++", Pearson, 2006.

SWE5409 Data Warehousing and Data Mining

This course contains topics of Data Warehousing, Data Warehouse Architecture, Design, Implementation & Maintenance, Data Mining Concepts, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis in Data Mining, Mining Complex Types of Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases, Applications, Trends in Data mining, spatial mining, and Web Mining.

Suggested Books:

1. P. Ponniah, "Data Warehousing Fundamentals", John Wiley, 2001.
2. M.H. Dunham, "Data Mining Introductory & Advanced Topics", Pearson Education, 2011.
3. H. Kamber, M. Kaufman, J. Pie, "Data Mining Concepts & Techniques", Third Edition, Morgan Kaufmann, 2012.

SWE5301 Minor Project-I

SWE5303 Artificial Intelligence

This course covers topics of AI Problems, Task Domains of AI, AI Techniques, Basic Problem solving Method: state space search, problem characteristics, Heuristic search Techniques, Knowledge Representation Knowledge Representation: using Predicate Logic: Unification, resolution. Natural deduction, using Rules, Structured Knowledge Representation, Programming Languages: Prolog or Lisp , Symbolic Reasoning under uncertainty, Statistical Reasoning, Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, , Neural Network, Genetic theorem, Expert Systems Research issues in different domains.

Suggested Books:

1. J E. Rich. K. Knight, "Artificial Intelligence", Tata McGraw Hill, Second Edition, 1992.
2. N.J. Nilsson, "Principles of AI", Narosa Publ. House, 1990.
3. D.W. Patterson, "Introduction to AI and Expert Systems", PHI, 1992.
4. M. Negnevitsky, "Artificial Intelligence: A Guide to Intelligent Systems", Second Edition, Addison-Wesley, 2005.

SWE5305 Information Retrieval

This course contains topics of Introduction and Search engine architecture, Search engine architecture, Retrieval models, Retrieval evaluation, classical evaluation metrics, e.g., Mean Average Precision, and modern advance, e.g., interleaving. Relevance feedback, Link analysis and Search applications, recommendation, personalization, and online advertising.

Suggested Books:

1. C. D. Manning, P. Raghavan and H. Schutze. "Introduction to Information Retrieval", Cambridge University Press, 2008.

SWE5307 Fuzzy Logic and Neural Networks

This course intends to introduce the functioning and application of fuzzy logic and neural networks. Classical & Fuzzy Sets: Properties, Operations and relations, Fuzzy sets, Membership, Uncertainty, fuzzy relations, cardinalities, membership functions. Fuzzy Logic System Components: Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods. Introduction to Neural Networks: Biological and Artificial Neuron Models, Characteristics, McCulloch-Pitts Model. Essentials of Artificial Neural Networks: Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules. Single Layer and Feed Forward Neural Networks. Associative Memories: Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory, Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms, Architecture of Hopfield Network. Applications.

Suggested Books:

1. S. Haykins, "Neural Networks- A comprehensive foundation", Pearson Education, 1999.

2. S. Rajasekharan and G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications", PHI Publication, 2003.

3. J. Yen, R. Langari, "Fuzzy Logic: Intelligence, Control and Information", First Edition, Pearson, 1998.

4. J.A. Freeman, D. Skapura, "Neural Networks", Pearson Education, 2002.

SWE5309 Software Project Management

This course contains topics of Project Management concepts, Process Framework, Project Planning Software Life Cycle Models, Artifacts of the Project Management Process, Cost and Scheduling Estimation Models, Project Management Techniques, Project Closure, Software Project Management Renaissance, Advance Topics in Software Project Management

Suggested Books:

1. W. S. Humphrey, "Managing the Software Process", Pearson Education, 1990.

2. W. Royce, "Software Project Management", Pearson Education, 2002.

3. P. Jalote, "Software Project Management in Practice", Pearson Education, 2002.

4. B. Hughes, "Software Project Management", Tata McGraw Hill, 1995.

SWE5201 SEMINAR

SWE5203 Probability and Statistics

This course contains topics of Introduction to Probability theory, Through set and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability and Axioms, Probability as a Relative Frequency, Joint and Conditional Probability, Random Variables, Distribution Function, Density Function, Operations on Random Variables, Sampling Distributions, Estimation, Testing of Hypotheses, Neyman-Pearson Fundamental Lemma, , Chi-square goodness of fit test and its applications, problems.

Suggested Books:

1. P. Peebles, "Probability random variables and random signal principles", Fourth Edition, Mc Graw Hill, 2013.
2. A. Poupolis, S. Pillai, "Probability: Random Variables and Stochastic Processes and Probability", Fourth Edition, Mc Graw Hill, 2017.
3. D. A. Lind, W. G. Marchal and S. A. Wathen, "Statistical Technics in Business and Economics", Thirteenth Edition, Tata McGraw Hill, 2007.

SEMESTER II

SWE502 Software Testing

The goal of the course is to make one understand software testing concepts and applications. Introduction: Software Failures, Testing Process, Some Terminologies, Limitations of Testing, The V Shaped Software Life Cycle Model. Functional Testing: Boundary Value Analysis, Equivalence Class Testing, Decision Table Based Testing, Cause Effect Graphing Technique. Essentials of Graph Theory: Graph introduction, Matrix Representation of Graphs, Paths and Independent Paths, Generation of a Graph from Program, Identification of Independent Paths. Structural Testing: Control Flow Testing, Data Flow Testing, Slice Based Testing, Mutation testing. Selection, Minimization and Prioritization of Test Cases for Regression Testing: Regression Testing, Regression Test Cases Selection, Reducing the Number of Test Cases, Risk Analysis, Code Coverage Prioritization Technique. Software Testing Activities: Levels of Testing, Debugging, Software Testing Tools. Web Based Testing: Functional Testing, User Interface Testing, Performance Testing, Configurability Testing, Database Testing, Security Testing.

Suggested Books:

1. Y. Singh, "Software Testing", 1st Ed., Cambridge University Press, 2012.
2. P. C. Jorgenson, Software Testing A Craftsman's approach, CRC Press, 1997.
3. B. Beizer, "Software Testing Techniques", Second Volume, Second Edition, Van Nostrand Reinhold, New York, 1990.

SWE504 Empirical Software Engineering

The goal of the course is to instill the concepts and applications of empirical software engineering. Introduction: What Is Empirical Software Engineering? Overview & Types of Empirical Studies, Empirical Study Process, Ethics, Importance and Basic Elements of Empirical Research, Some Terminologies. Systematic Literature Review, Software Metrics, Experimental Design, Mining Data from Software Repositories, Data Analysis and Statistical Testing, Model Development and Interpretation, Validity Threats, Reporting Results, Mining Unstructured Data, Case Study & Tools.

Suggested Books:

1. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.
2. B. Boehm, H. D. Rombach, M. V. Zelkowitz, "Foundations of Empirical Software Engineering: The Legacy of Victor R. Basili", Springer, 2010.

SWE5402 Software Design Patterns

This course gives an overview of software architecture and the various design patterns used. Envisioning Architecture: Defining, documenting and reconstructing software architecture. Creating Architecture: Quality Attributes, Moving from quality to Architecture, Architectural styles and patterns, Operations, Achieving qualities, shared information systems. Analyzing Software Architecture: Analyzing development qualities at the architectural level, SAAM, ATAM, CBAM, Architecture Reviews. Moving from Architecture to Systems Software: Product Lines, Building systems from off the shelf components, Reuse of Architectural assets within an organization. Patterns Definition: Pattern categories, Pattern Description, Patterns and Software Architecture, Pattern Systems, Classification, Selection, Design Patterns Catalog Creational Pattern, Structural Pattern, Behavioral Patterns, Pattern Community, Designing a document editor. Advanced studies.

Suggested Books:

1. E. Gamma, R. Helm, R. Johnson, J. Vlissides, G. Booch, "Design Patterns: Elements of Reuseable Object-Oriented Software", Addison Wesley, 1997.
2. L. Bass, P. Clements, R. Kazman, "Software Architecture in Practice", Pearson, 2013.
3. F. Buschmann, R. Meunier, H. Rohnert, P. Sommerlad, M. Stal, "Pattern-Oriented Software Architecture, A System of Patterns", First Edition, Wiley, 2013.

SWE5404 Soft Computing

This course contains topics of Soft Computing & Artificial Intelligence, Applications of Soft Computing, AI Search Algorithm, Predicate Calculus, Rules of Interference, Semantic Networks, Frames, Objects, Hybrid Models. Artificial Neural Networks, Back propagation Networks, Applications of NN. Fuzzy Logic and Fuzzy Sets , Fuzzy Arithmetic, Neuro - Fuzzy Modeling , Genetic Algorithms and Swarm Optimizations: Fitness Computations, Evolutionary Programming, Genetic Programming Parse Trees, Variants of GA, Applications.

Suggested Books:

1. S. Patnaik, B. Zhong, "Soft Computing Techniques in Engineering Applications", Springer, 2014.
2. H. J. Krogh, R.G. Palmer, "Introduction to the Theory of Neural Computation", Addison-Wesley, 1991.
3. M. Mitchell, "An Introduction to Genetic Algorithm", PHI, 1998.
4. S. Kaushik, "Artificial Intelligence", Cengage Learning, 2007.
5. J.A. Anderson, "An Introduction to Neural Networks", MIT Press, 1997.
6. G.J. Klir & B. Yuan, "Fuzzy Sets & Fuzzy Logic", PHI, 1996.

SWE5406 Machine Learning

The objective is to make the student understand the different supervised, unsupervised and reinforcement learning algorithms and choose the appropriate machine learning tool for different real-world examples. This course contains topics Machine Learning, Types of Machine Learning :Supervised, Unsupervised Learning, Reinforcement Learning, Categories of Supervised Learning; Predictive Modeling, Steps in Model Prediction: Metric Data Analysis, Attribute Reduction, Hypothesis Testing, Performance Evaluation Measures, Model Development, Model Development, Model Validation, Model Comparison Tests, Decision Trees, Artificial Neural Networks (Single-Layer Networks, Multi-layer Perceptron, Nearest Neighbor, Computing Distance. Dimensionality Reduction, Ensemble Learning. Research applications.

Suggested Books:

1. T. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. S. Shalev-Shwartz, S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
3. J. D. Kelleher, B. M. Namee, A. D'Arcy, "Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies", MIT Press, 2015.

SWE5408 Big Data Analytics

The objective is to get students exposed with the basic rudiments of business intelligence system, understand the modeling aspects behind business intelligence and understand the business intelligence life cycle and the techniques used in it. This course contains topics of Evolution of Big data, Big data characteristics, Big Data Use Cases, Advanced Analytical Theory and Methods, K-means, Decision Tree, Advanced Analytical Theory and Methods-Association Rules, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. Stream Memory, NoSQL Data Management For Big Data And Visualization, Review of Basic Data Analytic Methods using R.

Suggested Books:

1. P.C. Zikopoulos, C. Eaton, D. Deroos, T. Deutsch, J. Lapis, "Understanding Big Data", McGraw Hill, 2012.
2. J. Leskovec, A. Rajaraman, J. D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
3. B. Lublinsky, K.T. Smith, A. Yakubovich, "Professional Hadoop Solutions", Wiley, 2015.
4. T. White, "HADOOP: The definitive Guide", O Reilly, 2012.

SWE5410 Wireless and Mobile Computing

This course covers topics of Network Technologies and Cellular Communications, Discussion on Bluetooth & GSM. Introduction to Mobile Computing, Medium Access Control, Mobile Architecture, Mobile Network Layer, Mobile Transport Layer, Mobile Ad hoc Networks (MANETs), Wireless Sensor Networks, Protocols and Tools: Wireless Application Protocol WAP. (Introduction, protocol architecture, and treatment of protocols of all layers), J2ME and latest technologies.

Suggested Books:

1. R. Kamal, "Mobile Computing", Second Edition, Oxford Higher Education, 2002.
2. W. Stallings, "Wireless Communication and Networks", Pearson Education, 2003.

3. V. Garg, J. Wilkes, "Wireless and Personal Communications Systems", Prentice-Hall, 1996.

4. M. LotherMerk, S. Nicklaus, T. Stober, "Principle of Mobile Computing", Second Edition, Springer, 2003.

SWE5302 Minor Project II

SWE5304 Optimization Techniques

This course contains topics of Introduction to Linear Programming, Graphical method, The Simplex Method, Post optimality Analysis, Duality Theory and Sensitivity Analysis, Dynamic Programming, Integer Programming, Nonlinear Programming, Queuing Theory.

Suggested Books:

1. H.A. Taha, "Operations Research", Ninth Edition, Pearson Education, 2011.

2. J.K. Sharma, "Operations Research", Third Edition, Mcmillan, 2007.

3. F. Hiller & J. Lieberman, "Operations Research", Eighth Edition, Tata McGraw Hill, 2005.

4. K. Swarup, P.K. Gupta, M. Mohan, "Operations Research", Sultan Chand & Sons, 2017.

SWE5306 Pattern Recognition

This course contains topics of Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Decision Theory, Sufficient Statistics, Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent. Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Unsupervised Learning Algorithms, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks.

Suggested Books:

1. R. O. Duda, P. Hart, D. Stork, "Pattern Classification", Second Edition, Wiley, 2000.

2. C.M. Bishop,"Pattern Recognition and Machine Learning", Springer, 2007.

3. C.M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995.

4. S. Theodoridis, K. Koutroumbas, "Pattern Recognition", Fourth Edition, Academic Press, 2008.

SWE5308 Distributed Systems

This course covers topics of Distributed System Models, Transparency, Scalability, Inter-process Communication, Middleware, issues in design of Distributed systems: current & future, Communications, Process and Synchronization, Serializability, Resource Allocation, Distributed Shared Memory, Process Scheduling, Load Balancing & Load Sharing, Mutual Exclusion, Election algorithms. Distributed File Systems Overview of security techniques, Cryptographic algorithms , Digital signatures, Cryptography pragmatics.

Suggested Books:

1. A. S. Taenbaum, M. V. Steen, "Distributed Systems: Principles and Paradigms", Prentice Hall, 2015.
2. G. Coulouris, J. Dollimore, T. Kindberg, "Distributed Systems Concepts and Design", Addison Wesley, 1994.
3. A. Kshenkalyani, M.Singhal, "Distributed Computing", Cambridge University Press, 2008.

SWE5310 Natural Language Processing

This course contains topics Phases in natural language processing, applications. Words and Word Forms, Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Morphology, acquisition models, Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality, Web 2.0 Applications.

Suggested Books:

1. D. Jurafsky, J. H. Martin, "Speech and Language Processing", Second Edition, Pearson Education, 2009.
2. A. James, "Natural Language Understanding", Second Edition, Pearson Education, 1994.
3. A. Bharati, R. Sangal V. Chaitanya, "Natural Language Processing: A Paninian Perspective", PHI, 2000.
4. T. Siddiqui, U.S. Tiwary, "Natural Language Processing and Information Retrieval", OUP, 2008.

SWE5202 Research Methodology

This course contains topics of Foundation of Research and Problem Definition, Meaning, Objective and Importance of research, Types of research, steps involved in research, identification of research problem and its formulation. Research Design, Methods of research design, research process and steps involved, Literature Survey. Data Collection and Analysis,, Reporting of Research, Types of research report, Referencing and referencing styles, Indexing and citation of Journals, Reference management software like Mendeley, Intellectual property, Plagiarism.

Suggested Books:

1. C. R. Kothari, G. Garg, "Research Methodology Methods and Techniques", Third Edition, New Age International, 2019.
2. D. Cooper, P. Schindler, "Business Research Methods", Ninth Edition, Tata McGraw Hill, 2006.
3. J.W. Creswell, "Research design: Qualitative, quantitative, and mixed methods approaches", Sage publications, 2013.

SWE5204 Predictive Modelling

The course aims at introducing the framework of predictive modeling process to students. Introduction: classification & prediction, key ingredients of predictive models, goals of a regression analysis, regression models, data in a regression analysis. Data preparation: analyzing the metric data, outlier analysis, correlation analysis, attribute reduction methods, attribute extraction. Statistical tests: categories, one-tail and two-tail, Type I and Type II errors, interpreting significance results. Model

Development: data partition, attribute reduction, model construction, model validation, hypothesis testing, results interpretation, cross-validation. Hypothesis testing and model-comparison tests. Model evaluation: performance measures for categorical and continuous dependent variables, ROC analysis.

Suggested Books:

1. M. Kuhn and K. Johnson, "Applied Predictive Modelling", Springer Verlag, 2013.
2. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.
3. E.E. Frees, E.W. Derrig, and G. Meyers, "Predictive Modeling Techniques in Actuarial Science", Vol. I: Predictive Modeling Techniques. Cambridge University Press, 2014.

SWE5206 Operational Research

This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making. Introductory linear algebra: system of linear equations, matrices, rank and determinant of a matrix, linearly dependent and independent vectors, basis of a matrix. Linear programming: optimization problems, introduction to LP formulation, convex sets, extreme points, geometry of linear programs, basic feasible solutions, neighborhoods, local and global optima, profitable column, pivoting, simplex algorithm, graphical method. Duality: definition of the dual problem, primal-dual relationships, economic interpretation of duality, complementary slackness conditions. Transportation models: transportation algorithm, assignment model, hungarian method. Queuing models: elements of queuing model, exponential distribution, poisson distributions, poisson queuing models, single server model, multiple server model.

Suggested Books:

1. G. Hadley, "Linear Programming", Narosa, 2002.
2. H. A. Taha, "Operations Research-An Introduction", Prentice Hall, 8th Edition, 2008.
3. A. Ravindran, D. T. Phillips and J. J. Solberg, "Operations Research-Principles and Practice", John Wiley & Sons, 2005.

SEMESTER III

SWE601 Major Project I

SWE6401 Advances in Software Engineering

A primary goal of this course is to introduce advanced software engineering concepts and their usefulness. Topics include formal methods used in software development, cleanroom software engineering including its specification, design and testing, component-based software engineering, the process of web engineering and testing web applications, reengineering of business process and software, reverse engineering, restructuring and forward engineering, along with various approaches and tools for automated test data generation.

Suggested Books:

1. Y. Singh, "Software Testing", Cambridge University Press, 2012.
2. R.S. Pressman, "Software Engineering: A Practitioner's Approach", 7th Edition, Mc Graw Hill, 2017.
3. F. Buschmann, R. Meunier, H. Rohnert, P. Sommerlad, M. Stal, "Pattern-Oriented Software Architecture", John Wiley, 1996.

SWE6403 Cloud Computing

The goal of this course is to introduce the concepts and applications of cloud computing. Overview of Computing Paradigm and introduction to cloud computing: Recent trends in computing, Evolution of Cloud Computing, Cloud service providers, Properties, Characteristics & Disadvantages, Cloud computing vs. Cluster computing vs. Grid computing, Role of Open Standards. Cloud computing architecture, Role of networks and web services in cloud computing, Service models, Deployment Models. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Service management in Cloud Computing, Cloud Security.

Suggested Books:

1. B. Sosinsky, "Cloud Computing Bible", Wiley, 2010.
2. R. Buyya, J. Broberg, A. M. Goscinski, "Cloud Computing: Principles and Paradigms", Wiley, 2011.
3. N. Antonopoulos, L. Gillam, "Cloud Computing: Principles, Systems and Applications", Springer, 2012.
4. R. L. Krutz, R. D. Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley, 2010.

SWE6405 Things of the Internet

This course contains topics of Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs IoT enabaled Technologies , IoT and M2M , Introduction to Python , IoT Physical Devices and Endpoints , IoT Physical Servers and Cloud Offerings – Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework designing a RESTful web API.

Suggested Books:

1. A. Bahga, V. Madisetti, "Internet of Things – A Hands-on Approach", University Press, 2015.
2. M. Richardson, S. Wallace, "Getting Started with Raspberry Pi", O'Reilly, 2014.
3. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos, D. Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", First Edition, Academic Press, 2014.
4. B. Scholz-Reiter, F. Michahelles, "Architecting the Internet of Things", Springer, 2011.

SWE6407 Multimedia Applications

This course contains topics of Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Outline Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. Audio and Speech , Images and , Multimedia and Hypermedia, Hypermedia Presentation.

Suggested Books:

1. T. Vaughan, "Multimedia: Making it work", Tata McGraw-Hill, Ninth Edition, 2017.
2. R. Aggarwal, B. B Tiwari, "Multimedia Systems", Excel Publication, 2007.
3. Z. Li & M.S. Drew, "Fundamentals of Multimedia", Pearson Education, 2009.
4. D. Hillman, "Multimedia Technology and Application", Galgotia Publication, 2000.

SWE6409 Information Theory and Coding

This course is an introduction to various information theory concepts and applications. Introduction to Probability, Elementary Theorems, Random Variable, Uncertainty and Information, Shannon Entropy, Joint and conditional Entropies Mutual Information, Uniquely decipherable and Instantaneous codes, Noiseless coding problem. Source coding Theorem, Block coding, construction of Optimal codes, Huffman's & Shannon – Fano methods. Discrete memory less channel, channel capacity BSC and other channels. Information measure for continuous ensembles capacity of AWGN channel. Error control coding. The channel coding Theorem, Application to BSC , Source Coding with fidelity criteria. Types of codes, error and error control strategies, Linear block codes, syndrome and error detection, Minimum distance, Error detecting and correcting capabilities of a block code, Syndrome decoding, Hamming codes. Cyclic codes, Generator and parity, Latest Research.

Suggested Books:

1. R. B. Ash, "Information Theory", Dover Science Publications, 1965.
2. T. M. Cover, J.A. Thomas, "Elements of Information Theory", John Wiley & Sons, 2006.
3. S. Lin, D. J. Costello Jr, "Error Control coding: Fundamental & Application", Prentice Hall, 1983.
4. C. E. Shannon, W. Weaver, "A Mathematical Theory of Communication", University of Illinois Press, 1998.

SWE6301 Agile Methods

This course is an introduction to agile methodology and how it is practiced. Introduction: Iterative development, evolutionary and adaptive development, evolutionary requirement analysis, evolutionary and adaptive planning, incremental delivery, evolutionary delivery. Agile and its significance: Classification of methods, the agile manifesto, agile project management, sustainable discipline, research evidence. Agile Methodology: Overview, lifecycle work products, roles and practices values, sample projects, adoption strategies. Case Study. Agile Practicing and Testing.

Suggested Books:

1. C. Larman, "Agile and Iterative Development – A Manager's Guide", Pearson Education, 2004.
2. Elisabeth Hendrickson Quality Tree Software Inc, "Agile Testing", 2008.
3. A. Cockburn, "Agile Software Development series", Safari Books, 2001.

SWE6303 Software Reliability

This course gives a detailed introduction to software reliability concepts, how it can be measured and improved. Introduction to System Reliability: Reliability mathematics, probability distributions, system reliability, maintainability and availability, designing for higher reliability, redundancy. System Reliability Concepts: Software and hardware reliability, basic concepts, reliability model classification, software reliability growth models, markovian models. Non-homogeneous poisson process models: NHPP models, Musa models, Okumoto model, Yamada delayed S-shaped model, Imperfect debugging models, Kapur- Garg model, Subburaj-Gopal model for the learning phenomenon, Subburaj-Gopap-Kapur versatile debugging model. Comparison of software reliability models. Advanced topics in software reliability.

Suggested Books:

1. J. D. Musa, A. Iannino, K. Okumoto, "Software Reliability – Measurement, Prediction, Application, Series in Software Engineering and Technology", McGraw Hill., 1987.
2. M. Lyu, "Handbook of Software Reliability Engineering", IEEE Computer Society Press, 1996.
3. J. D. Musa, "Software Reliability Engineering", Tata McGraw Hill, 1999.
4. P. D. T. O'Connor, "Practical Reliability Engineering", Fourth Edition, John Wesley & sons, 2003.

SWE6305 Cluster and Grid Computing

This course contains topics of Cluster and Grid computing, Meta-computing, Web services and Grid Computing, e-Governance and the Grid, OGSA and WSRF, Technologies and Architectures for Grid Computing- Issues, Functional requirements, Web Services and the Service Oriented Architecture, Globus Toolkit, GT4 Architecture, GT4 Containers, The Grid and Databases, Cluster Computing, Cluster Middleware, Networking, Protocols and I/O for clusters, Setting Up and Administering a Cluster, Cluster Technology for High Availability, Process Scheduling, Load Sharing and Load Balancing.

Suggested Books:

1. W. Gropp, E. Lusk, T. Sterling, "Beowulf Cluster Computing with Linux", Second edition, MIT Press, 2003.
2. B. Jacob, M. Brown, K. Fukul, N. Trivedi, "Introduction to grid computing", IBM, 2005.
3. G. F. Pfister, "In Search of Clusters: The ongoing battle in lowly parallel computing", Second Edition, PHI, 1998.
4. C.S.R. Prabhu, "Grid and Cluster Computing", PHI, 2008.
5. R. Buyya, "High Performance Cluster Computing: Architectures and Systems", Volume 1, Pearson Education, 2008.

SWE6307 Software Quality & Metrics

The primary objective of the course is to make one understand software quality concepts and associated metrics to deliver good quality maintainable software. Introduction to software quality: What is software quality? software quality attributes, elements of a quality system, software quality models. Software metrics, their categories and application areas, measurement scales, analyzing metric data, metrics for measuring size, structure and software quality. Software maintenance: categories, challenges, maintenance of object-oriented software, software rejuvenation, estimation

of maintenance effort, configuration management, regression testing. Case study pertaining to software quality improvement.

Suggested Books:

1. Y. Singh, R. Malhotra, "Object-Oriented Software Engineering", PHI Learning, 2012.
2. S.H. Kan, "Metrics and Models in Software Engineering", Second Edition, Pearson Education, 2003.
3. A. Basu, "Software Quality Assurance Testing and Metrics", PHI Learning, 2015.

SWE6309 Swarm and Evolutionary Computing

The course is designed to introduce the basic concepts of evolutionary and swarm computing along with their applications. Introduction to Evolutionary Computing: Components, global optimization, evolution strategies, fitness functions, learning classifier systems, parameter control, multi-modal problems. Swarm Intelligence: Its application to optimization problems, particle swarm optimization. Genetic Algorithm: Basics, reproduction, cross-over and mutation, Genetic algorithm convergence, Genetic programming. Hybrid Methods and Multi-objective Evolutionary Algorithms: Variants of Particle Swarm optimization and Genetic Algorithm, their hybridization, hybrid Multi-objective Optimization algorithms. Other recent algorithms: Cockoo search algorithm, Artificial Bee Colony Optimization, Ant Colony Optimization, Fire-fly algorithm, Bacterial Foraging, Application to the travelling salesman problem. Application to real world optimization problems.

Suggested Books:

1. A. P. Engelbrech, "Computational Intelligence", Second Edition, John Wiley & Sons, 2008.
2. M. Mitchell, "An Introduction to Genetic Algorithm", MIT Press, 1996.
3. D. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley, 1989.
4. A.E Eiben, J.E. Smith, "Introduction to Evolutionary Computing", Second Edition, Springer, 2007.
5. K. DeJong, "Evolutionary Computation: A Unified Approach", MIT Press, 2006.

SWE6201 Data Security & Privacy

This course contains topics of Introduction to Data Security, Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, Modern Block Ciphers, Public-key cryptography Principles, Latest Trends and solutions in Information Security, IP Security, Web Security: Secure Socket Layer(SSL) and transport layer security, TSP, Secure Electronic Transaction (SET), Electronic money, WAP security, firewall design principals, Virtual Private Network (VPN) security.

Suggested Books:

1. W. Stallings, "Cryptography and Network Security", William Stallings, Seventh Edition, PHI, 2017.
2. Jan C A, "Basic Methods of Cryptography", Cambridge University Press, 2000.
3. T. Calabrese, "Information Security Intelligence: Cryptographic Principles & Applications", Thomson Learning., 2003.

4. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2003.

5. D. Elizabeth, R. Denning, "Cryptography and Data Security", Addison Wesley, 1992.

SWE6203 Bio-Informatics

This course contains topics of Algorithms For Bioinformatics, Pattern Matching And Clustering, Exact Pattern Matching , Clustering Basics, Multiple Sequence Alignment: Bioinformatics – Techniques And Applications, Words method of alignment, Macromolecular Structure Analysis , Numerical And Biostatistical Methods: Distributions – Binomial, Poisson and Normal, Handling Univariate, Bivariate and Multivariate data- Introduction to Probabilities, Interval Estimation.

Suggested Books:

1. N. C. Jones, P. A. Pevzner, "An Introduction to Bioinformatics Algorithms", MIT Press, 2005.

2. C. Gibas, P. Jambeck, "Developing Bioinformatics Computer Skills", O'Reilly Media,Inc, 2001.

3. S. Schulze-Kremer, "Molecular Bioinformatics: Algorithms and Applications", Walter de Gruyter, 1996.

4. G. W. Collins, "Fundamental Numerical Methods and data analysis", Harvard university Press, 2003.

SWE6205 Statistical Tools

This course contains topics of Review of Probability and Distributions, Rules for probability, random variables and their distributions, moments, special discrete and continuous distributions, laws of large numbers and central limit theorem, sampling distributions. Parametric Methods, Testing of Hypotheses , Multivariate Analysis, Nonparametric Methods, Kolmogorov Smirnov one sample statistics, sign test, Wilcoxon signed rank statistics, two sample problems, Mann-Whitney-Wilcoxon tests, scale problems, KolmogorovSmirnov two sample criterion, Hoeffding's U-statistics.

Suggested Books:

1. V.K. Rohatgi, A.K. Md.E.Saleh, "An Introduction to Probability and Statistics", Wiley, 2008.

2. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Fifth Edition, Academic Press, 2014.

3. E.J. Dudewicz, S.N. Mishra, "Modern Mathematical Statistics", Wiley, 1988.

4. T. W. Anderson, "An Introduction to Multivariate Analysis", Wiley, 2009.

5. J.D. Gibbons, S. Chakraborti, "Nonparametric Statistical Inference", Fourth Edition, Marcel Dekker, 2003.

Semester IV

SWE652 Research Project

SWE602 Major Project II

DEPARTMENT OF INFORMATION TECHNOLOGY

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Information Systems)

Programme Specific Outcomes

Post graduate student will

1. Apply the fundamentals of mathematics, science and engineering knowledge to understand, analyse and develop computer programs in the areas related to algoritms, multimedia, big data analytics, machine learning. artificial intelligence and networking for efficient design of computer-based systems of varying complexity.
2. Apply appropriate techniques and modern engineering hardware and software tools for the design and integration of information system and related technologies, to engage in lifelong learning for the advancement of technology and its adaptation in multi-disciplinary environments.
3. Implementation of professioanl engineering solutions for the betterment of society, keeping the environmental context in mind, be aware of professional ethics and be able to communicate effectively.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN INFORMATION SYSTEMS (ISY)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	ISY501	Linear Algebra and Probability	Core	4	3	0	2	15	25	20	40	-	17
	2	ISY503	Data Structure and Algorithm	Core	4	3	0	2	15	25	20	40	-	
Group B	3	ISY5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	ISY5301/5303/.....	Elective 2	Elective	3	3/2	0	0/2	20 /15	0/25	30 /20	50 /40	-	
	5	ISY5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	ISY502	High Performance Computing system	Core	4	3	0	2	15	25	20	40	-	17
	2	ISY504	Computer Network and Application	Core	4	3	0	2	15	25	20	40	-	
Group D	3	ISY5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	ISY5302/5304/.....	Elective 5	Elective	3	3/2	0	0/2	20 /15	0/25	30 /20	50 /40	-	
	5	ISY5202/5204/...../ UEC5202/5204/.....	Elective6/	Elective	2	2/0	0	0/4	20/0	0/30	30/0	50/0	0/70	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	ISY651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	ISY601	Major Project I	Core	3						40	60		12
	2	ISY6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	ISY6301/6303/.....	Elective 8	Elective	3	3/2	0	0/2	20 /15	0/25	30 /20	50 /40	-	
	4	ISY6201/6203/.....	Elective 9	Elective	2	0	0	2	0	100	0	0	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group F	1	ISY652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	ISY602	Major Project II	Core							40	60		12

List of Elective Courses

LIST OF ELECTIVES :

	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	ISY5401	Advanced Computer Graphics	Elective	4	3	0	2	15	25	20	40	-
	2	ISY5403	Artificial Neural network		4	3	0	2	15	25	20	40	-
	3	ISY5405	Big Data Analytics		4	3	0	2	15	25	20	40	-
	4	ISY5407	Data System Implementation		4	3	0	2	15	25	20	40	-
	5	ISY5409	Image Analysis		4	3	0	2	15	25	20	40	-
	6	ISY5411	Privacy and Security in Online Social Media		4	3	0	2	15	25	20	40	-
	7	ISY5413	Embedded System		4	3	0	2	15	25	20	40	-
	8	ISY5415	Digital and Cyber Forensics		4	3	0	2	15	25	20	40	-

	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	ISY5301	Artificial Intelligence	Elective	3	3	0	0	20	0	30	50	-
	2	ISY5303	Pattern analysis		3	2	0	2	15	25	20	40	-
	3	ISY5305	Business Intelligence and data warehousing		3	3	0	0	20	0	30	50	-
	4	ISY5307	Edge computing		3	3	0	0	20	0	30	50	-
	5	ISY5309	Financial data analytics		3	3	0	0	20	0	30	50	-
	6	ISY5311	Foundation to computer security		3	3	0	0	20	0	30	50	-
	7	ISY5313	Information Audit		3	3	0	0	20	0	30	50	-
	8	ISY5315	Information Integration and Data Analytics		3	2	0	2	15	25	20	40	-
	9	ISY5317	Linear Optimization		3	3	0	0	20	0	30	50	-
	10	ISY5319	Management Information System		3	3	0	0	20	0	30	50	-
	11	ISY5321	Multi agent system		3	3	0	0	20	0	30	50	-
	12	ISY5323	Privacy in location based services		3	3	0	0	20	0	30	50	-
	13	ISY5325	Probabilistic Graphical Models		3	2	0	2	15	25	20	40	-
	14	ISY5327	Software Engineering		3	2	0	2	15	25	20	40	-
	15	ISY5329	Theory of modern cryptography		3	2	0	2	15	25	20	40	-

	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	ISY5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-
	2	ISY5203	Latest Research in information technology		2	2	0	0	20	0	30	50	-
	3	ISY5205	Optimization tools		2	2	0	0	20	0	30	50	-

	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	ISY5402	Advanced operating system	Elective	4	3	0	2	15	25	20	40	-
	2	ISY5404	Cloud computing and virtualization		4	3	0	2	15	25	20	40	-
	3	ISY5406	Foundation of information theory and coding		4	3	0	2	15	25	20	40	-
	4	ISY5408	Internet security and privacy		4	3	0	2	15	25	20	40	-
	5	ISY5410	Machine learning		4	3	0	2	15	25	20	40	-
	6	ISY5412	Mobile application		4	3	0	2	15	25	20	40	-
	7	ISY5414	Semantic web		4	3	0	2	15	25	20	40	-
	8	ISY5416	Smart sensing for internet of things		4	3	0	2	15	25	20	40	-
3	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	ISY5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	ISY5304	Advanced computer vision		3	3	0	0	20	0	30	50	-
	3	ISY5306	Ad-Hoc wireless network		3	3	0	0	20	0	30	50	-
	4	ISY5308	Advanced topic in mobile computing		3	3	0	0	20	0	30	50	-
	5	ISY5310	Applied cryptography		3	3	0	0	20	0	30	50	-
	6	ISY5312	Collaborative filtering		3	3	0	0	20	0	30	50	-
	7	ISY5314	Cyber security and law		3	3	0	0	20	0	30	50	-
	8	ISY5316	Deep learning		3	2	0	2	15	25	20	40	-
	9	ISY5318	Digital watermarking and Steganalysis		3	3	0	0	20	0	30	50	-
	10	ISY5320	Distributed Data Mining		3	3	0	0	20	0	30	50	-
	11	ISY5322	Graph Theory		3	3	0	0	20	0	30	50	-
	12	ISY5324	Network anonymity and privacy		3	3	0	0	20	0	30	50	-
	13	ISY5326	Topics in computer security		3	3	0	0	20	0	30	50	-
	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	ISY5202	Research problem formulation	Elective	2	0	0	4	-	30	-	-	70
	2	ISY5204	Laboratory on advanced topics		2	0	0	4	-	30	-	-	70

	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	ISY6401	Biometrics Systems	Elective	4	3	0	2	15	25	20	40	-
	2	ISY6403	Natural Language Processing		4	3	0	2	15	25	20	40	-
	3	ISY6405	Network security		4	3	0	2	15	25	20	40	-
	4	ISY6407	Robotics		4	3	0	2	15	25	20	40	-
	5	ISY6409	Ethical Hacking		4	3	0	2	15	25	20	40	-
	6	ISY6411	Secure Coding		4	3	0	2	15	25	20	40	-
	7	ISY6413	Mobile Computing.		4	3	0	2	15	25	20	40	-
	S.No	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	ISY6301	Bioinformatics	Elective	3	3	0	0	20	0	30	50	-
	2	ISY6303	Data Mining		3	3	0	0	20	0	30	50	-
	3	ISY6305	Data Warehousing		3	3	0	0	20	0	30	50	-
	4	ISY6307	Dev-Ops		3	3	0	0	20	0	30	50	-
	5	ISY6309	Evolutionary computing		3	3	0	0	20	0	30	50	-
	6	ISY6311	GPU computing		3	3	0	0	20	0	30	50	-
	7	ISY6313	Information Retrieval		3	2	0	2	15	25	20	40	-
	8	ISY6315	Intelligent system and interface		3	2	0	2	15	25	20	40	-
	9	ISY6317	Introduction to cognitive science		3	3	0	0	15	25	20	40	-
	10	ISY6319	Introduction to spatial computing		3	2	0	2	15	25	20	40	-
	11	ISY6321	Malware Analysis		3	2	0	2	15	25	20	40	-
	12	ISY6323	Real time operating system		3	2	0	2	15	25	20	40	-
	13	ISY6325	Soft computing		3	3	0	0	20	0	30	50	-
	14	ISY6327	Statistical machine learning		3	2	0	2	15	25	20	40	-
	15	ISY6329	Web intelligence and big data analytics		3	3	0	0	20	0	30	50	-
	16	ISY6331	Quantum computing		3	3	0	0	20	0	30	50	-
	17	ISY6333	Intrusion detection and prevention		3	3	0	0	20	0	30	50	-
	S.No		Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	18	ISY6201	Open Area Research Seminar	Elective	2	0	0	2	-	100	-	-	-

SEMESTER I

Courses

ISY501 Linear Algebra and Probability

Introduction to Linear Algebra and Matrices: Matrices and Linear Transformations, Rank, Determinant, trace of a matrix. Solving simultaneous equations using matrices,Gaussian Elimination, Overdetermined and underdetermine systems, Inverse, pseudo inverse. Condition number of a matrix, eigenvalues, eigenvectors, singular values, singular vectors.

Orthogonality: Inner Product, Orthogonality, Gram-Schmidt Orthogonalization, Vector and Matrix Norms - Applications to optimization problems and graph theory, machine learning.

Introduction to Random Variables and Random Vectors: Discrete and continuous random variables, random vectors. Transformation of continuous random variables and vectors by deterministic functions. Density functions of transformed continuous random variables.

Introduction to Random Processes: Statistical averages, ensemble and time averages. Random process, Bernoulli random process, binomial process. Weak and strict sense stationarity of a random process.

Estimation of parameters from data: method of moments, method of maximum likelihood. Tests of fit: Chi-Squared, Student-t test. Cramer-Rao bound on estimators. Comparison of two different distributions of the same random variable/vector..

Suggested Books:

1. Gilbert Strang , Linear Algebra and Its Applications - Fourth Edition- Cengage Learning, 2006
2. Papoulis and Unnikrishnan Probability, Random Variables and Stochastic Processes, Fourth Edition, 2002, available in paperback
3. W B Davenport, Probability and Random Processes - an introduction for application scientists and engineers, McGraw HilL,1970
4. Probability and Statistics with Reliability, Queuing, and Computer Science Applications - Kishore S Trivedi, PHI, July 2016
5. Kenneth Hoffman and Ray Kunze Linear Algebra (second edition), Prentice Hall India, 2013
6. Cheney and Kincaid Linear Algebra (Second Edition) , Jones and Bartlett learning, 2014"

ISY503 Data Structure and Algorithm

Introduction: Introduction to Algorithmic, Complexity- Time-Space Trade off. Introduction to C programming through Arrays, Stacks, Queues and Linked lists.

Trees: Basic Terminology, Traversals, Binary search trees, optimal and average BST's. 2-4 trees, Applications of Binary Search Trees, Complete Binary trees, Extended binary trees.

Introduction to algorithms: Concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations. Growth of Functions, Master's Theorem,

Searching and Searching: Linear Search, Binary search, Insertion Sort, Quick sort, Merge sort, Heap sort, Radix Sort.

Graphs: Terminology and Representations, Graphs & Multi-graphs, Directed Graphs, Representation of graphs, Breadth first search and connected components. Depth first search in directed and undirected graphs and strongly connected components.

Spanning trees: Prim's and Kruskal's algorithm, union-find data structure. Dijkstra's algorithm for shortest paths, shortest path tree. Directed acyclic graphs: topological sort and longest path. Dynamic programming: Principles of dynamic programming. Applications: Matrix multiplication, Travelling salesman problem.

Suggested Books:

1. Aaron M. Tenenbaum, Data Structures Using C, Pearson Education India, 1990.
2. T .H .Cormen, C .E .Leiserson, R .L . Rivest "Introduction to Algorithms", 3rd Ed., PHI, 1956
3. E. Horowitz, S. Sahni, and S. Rajsekaran, "Fundamentals of Computer Algorithms," Galgotia Publication R.L. Kruse, B.P. Leary, C.L. Tondo, 2011

Elective 1

ISY5401 Advanced Computer graphics

Discrete models. Visibility: zBuffer, Binary Space Partitioning, Volume rendering: Global Illumination and Rendering Equation ,ray-tracing, splatting, texture based, Bidirectional Ray Tracing, Monte-carlo Ray Tracing.

Iso surface reconstruction. Transformation of discrete volume data to polygonal representations. Radiosity: Full Matrix Representation, Faster Methods Mesh topologies and mesh simplification.

Point Based Representation, Global Illumination for Point Based Representations, Image Based Rendering, Environmental Matting, GPU programming, Modelling curves and surfaces.

Visualization techniques: Visual aspects based on perception. Particle rendering. Algorithms for programmable graphics hardware), Applied visualization.

Suggested Books:

1. Edward Angel.,Interactive Computer Graphics - A Top-Down Approach Using OpenGL (5/e), Pearson; 6 edition (31 March 2011)
2. F. S. Hill Jr. and S. M. Kelley, Computer Graphics using OpenGL (3/e), Pearson; 3 edition (20 December 2006).
3. D. D. Hearn and M. P. Baker, Computer Graphics with OpenGL (3/e)) ,Hearn, Baker & Carithers 2013.

ISY5403 Artificial Neural network

Introduction, history, structure and function of single neuron, neural net architectures, neural learning, use of neural networks.Supervised learning, single layer networks, perceptions, linear separability, perceptions training algorithm, guarantees of success, modifications.

Multiclass networks-I, multilevel discrimination, preliminaries, back propagation, setting parameter values, theoretical results.Accelerating learning process. Accelerating learning process, application, mandaline, adaptive multilayer networks.

Prediction networks, radial basis functions, polynomial networks, regularization, unsupervised learning, winner take all networks,Learning vector quantizing Learning vector quantizing, counter propagation networks, adaptive resonance theorem, toplogically organized networks, distance based learning, neo-cognition.

Associative models, hop field networks, brain state networks, Boltzmann machines, hetero associations.Optimization using hop filed networks, simulated annealing, random search, evolutionary computation.

Suggested Books:

1. S.Russel, P.Norvig,,Artificial Intelligence – A Modern Approach. Second Edition, PHI/ Pearson Education, November 5, 2011.
2. B. Yagna Narayana, Artificial Neural Networks, PHI (30 August 2004)
3. E.Rich and K.Knight. Artificial Intelligence , 2nd Edition,McGraw-Hill Education,2009.

ISY5405 Big Data Analytics

Introduction – distributed file system – Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce.

Big Data –Apache Hadoop & Hadoop EcoSystem – Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce - Data Serialization.

Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands , Anatomy of File Write and Read., NameNode, Secondary NameNode, and DataNode, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering –Monitoring & Maintenance.

Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions.

HBase concepts- Advanced Usage, Schema Design, Advance Indexing - PIG, Zookeeper - how it helps in monitoring a cluster, HBase uses Zookeeper

Data Analytics with R:- Machine Learning : Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR.

Suggested Books:

1. C. J. Date Addison-Wesley , Introduction to Database Systems (Links to an external site.)Links to an external site.. 8th Ed. Publisher: Addison-Wesley; 8 edition (August 1, 2003) ISBN-10: 0321197844/ ISBN-13: 978-0321197849.
2. R. A. Mata-Toledo and P. Cushman ,Fundamentals of SQL Programming (Links to an external site.)Links to an external site.. Schaum's Outline Series. McGraw-Hill (2000).
3. H. Garcia-Molina and et al. Prentice Hall , Database Systems the Complete Book (Links to an external site.)Links to an external site; 2ndEdition (June 15, 2008). ISBN-10: 0131873253 / ISBN-13: 978- 013187325 (Links to an external site.)Links to an external site.
4. R. Elmasri and S. Navathe . Addison-Wesley ,Fundamentals of Database Systems (Links to an external site.)Links to an external site. Addison-Wesley; 6 edition (April 9, 2010) ISBN-10: 0136086209 / ISBN-13: 978-0136086208

ISY5407 Data System Implementation

Relational Databases Overview: Relational data model concepts, integrity constraints, Keys domain constraints, referential integrity, assertions, triggers, foreign key relational algebra, relational calculus, domain and tuple calculus, SQL data definition queries and updates in SQL

Data Base Design: Functional dependencies, normal forms, 1NF, 2NF, 3NF and BCNF, multi-valued dependencies fourth normal form, join dependencies and fifth normal form. Inclusion dependencies, lossless join decompositions, normalization ,

File Organization: Indexing and Hashing Overview of file organization techniques, Indexing and Hashing- Basic concepts, Static Hashing, Dynamic Hashing, Ordered indices, Multi-level indexes, B-Tree index files, B+- Tree index files, Buffer management

Transaction processing concepts: Transaction processing system, schedule and recoverability, Testing of serializability, Serializability of schedules, conflict & view serializable schedule, recovery from transaction failures, deadlock handling. Concurrency Control Techniques.

Query Evaluation: SQL queries, Relational Algebra and Equivalence Rules, Tuple-based Evaluation

Cost-based Query Optimisation: Join Algorithms, Cost of an Evaluation Plan, Search Space Exploration, Selection of Evaluation Plan.

Suggested Books:

1. C. J. Date Addison , Introduction to Database Systems (Links to an external site.)Links to an external site, Wesley. 8th Ed. Publisher: Addison-Wesley; 8 edition (August 1, 2003) ISBN-10: 0321197844/ ISBN-13: 978-0321197849.
2. R. A. Mata-Toledo and P. Cushman , Fundamentals of SQL Programming (Links to an external site.)Links to an external site. Schaum's Outline Series. McGraw-Hill (2000).
3. H. Garcia-Molina and et al , Database Systems the Complete Book (Links to an external site.) Links to an external site. Prentice Hall; 2ndEdition (June 15, 2008). ISBN-10: 0131873253 / ISBN-13: 978- 013187325 (Links to an external site.)Links to an external site.
4. Fundamentals of Database Systems (Links to an external site.)Links to an external site. by R. Elmasri and S. Navathe . Addison-Wesley; 6 edition (April 9, 2010) ISBN-10: 0136086209 / ISBN-13: 978-0136086208

ISY5409 Image Analysis

Fundamental steps in DIP, concept of visual information, image formation model, image sampling and quantization, digital image representation, spatial and gray level resolution, relationship between pixels, application of image processing system.

Introduction to Multidimensional signals and systems, 2D-Signals, 2D systems, classification of 2D system, 2D convolution, 2D Z-transform, Image Transform: 2DDFT, discrete cosine, discrete sine, Haar, Walsh, Hadamard, Slant, KL, SVD, Hough,Radon, Ridgelet.

Image enhancement; Spatial domain: linear transformation, image negative, grey level shifting, non-linear transformation, logarithmic transformation, exponential transformation, grey level slicing, bit plane slicing, image averaging, mask processing, histogram manipulations.

Image Restoration :Image Restoration – degradation model, Properties, Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters –

Optimum Notch Filtering – Inverse Filtering – Wiener filtering

Image Segmentation :Edge detection, Edge linking via Hough transform – Thresholding – Region based segmentation – Region growing – Region splitting and merging – Morphological processing-erosion and dilation.

Suggested Books:

1. Rafael C. Gonzalez, Richard Eugene Woods "Digital Image Processing" 3rd Edition, 2008
2. Anil K. Jain,Fundamentals of Digital Image Processing Pearson, 2002
3. Kenneth R. Castleman,Digital Image Processing Pearson, 2006.
4. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,Digital Image Processing using MATLAB Pearson Education, Inc., 2011.

ISY5411 Privacy and Security in Online Social Media

Privacy and Security in Online Social Media, Online Social Networks, security services(authentication, availability, integrity, confidentiality), Recognizing Your Digital Friends, Encryption for Peer-to-Peer Social Networks, Understanding User Privacy Perceptions, Cybercrime, Privacy Usable security, Trust Management and Issues

Data collection from social networks, challenges, opportunities, and pitfalls in online social networks, APIs, Collecting data from Online Social Media.

Trust, credibility, and reputations in social systems, Online social Media and Policing, Information privacy disclosure, revelation and its effects in OSM and online social networks

Spam, Phishing and identity theft in OSM & Identifying fraudulent entities in online social networks, Crowdsourcing and Ethics, Interdisciplinary Impact Analysis of Privacy in Social Networks, Legal and policy issues in privacy and security, Anonymity in a networked world, e crime, identity resolution.

Web portal, Credibility scoring Social network graph, bitcoin system, android security.

Suggested Books:

1. Gavin Bell ,Building Social Web Applications, Publisher: Shroff/O'Reilly; First edition, 26 September 2009
2. Toby Segaran ,Programming Collective Intelligence: Building Smart Web 2.0 Applications,(Author), Publisher: O'Reilly Media, 16 August 2007.
3. Altshuler, Y. and Elovici, Security and Privacy in Social Networks, Publisher: Springer,2013.

ISY5413 Embedded System

Introduction: fundamentals of embedded systems, embedded system architecture, classifications of embedded systems, fundamentals of embedded processor and microcontrollers, embedded software in a system, examples of embedded systems. CISC vs. RISC.

The 8051 Architecture: 8051 microcontrollers, I/O Ports and Circuits, Timers Counters, Serial Interface, Interrupts. 8051 Assembly Language Programming: Registers in the 8051, 8051 Assembly Assembling and Running an 8051 Programs.

Programming in C: Fundamental concepts of C programming, Examples on different concepts, Control

structure, Functions, Storage classes, Pointers, structure, union, object-oriented programming, Assembly language intro, memory organization.

Assembly language programming: Instruction set and Programming, Immediate Addressing, Register Addressing Direct Addressing, Indirect Addressing, Indexed Addressing.

I/O Programming: PIC I/O ports, I/O bit manipulation programming, timers/counters, programming to generate delay and waveform generation, I/O programming.

PIC Microcontrollers: Introduction PIC Microcontroller, PIC16F877A Architecture and Instruction Set, I/O Ports and SFRs, Interrupts, Timers.

Serial Communication Protocols ,Introduction to Timers & Counters, Difference between Timer and Counter.

Suggested Books

1. Shibu K. V. (TMH),Introduction to Embedded Systems, McGraw Hill Education (15 June 2009)
2. F. Vahid (John Wiley),Embedded System Design – A unified hardware and software introduction, John Wiley & Sons; ISBN: 0471386782. Copyright (c) 2002.
3. chuck helebuyck ,Programming PIC microcontrollers with PIC basic; 1st Edition (later printing) edition (December 6, 2002).

ISY5415 DIGITAL AND CYBER FORENSICS

Introduction to digitalforensics, Digital evidence and investigations, Real life examples of digital crime, Challenging aspects of digital forensics, introduction to intellectual property rights and professional ethics. Computer crime investigation process: The Investigation process, preparing a computer investigation..

Overview of Types of computer forensics i.e. Media Forensics, Network forensics (internet forensics), Machine forensic, Email forensic (e-mail tracing and investigations). Digital forensics of image, audio etc files.

Live Data collection and investigating windows environment: windows Registry analysis, Gathering Tools to create a response toolkit (Built in tools like netstat , cmd.exe , nbtstat , arp , md5sum ,regdmpetc and tools available as freeware like Fport , Pslistetc) ,

Live Data collection and investigating UNIX environment Forensic tools and report generation: Recovery of Deleted files in windows, Analyzing network traffic, sniffers, Ethical Hacking, Hardware forensic tools like Port scanning and vulnerability assessment tools like Nmap ,Netscanetc .Password recovery, Mobile forensic tools

Suggested Books:

1 Mandia, Kevin, Prosise, Chris, and Pepe, Matt," Incident Response &Computer Forensics", McGraw-Hill, July 17, 2003

2. Beebe, Nicole Lang, and Jan Guynes Clark, "A Hierarchical, Objectives-Based Framework for the Digital Investigations Process June 2005.

3. Nelson, Bill, Amelia Phillips, Frank Enfinger, and Christopher Steuart," Guide to Computer Forensics and Investigations", Thompson Course Technology, Boston, 2006

Elective 2

ISY5301 Artificial Intelligence

Introduction: AI Problems, Task Domains of AI, AI Techniques: search knowledge, abstraction. Introduction to Intelligent program and Intelligent agents. Problem Solving: Basic Problem-solving Method: state space search, problem characteristics, Production systems characteristics, issues in design of Intelligent search algorithm.

Heuristic search Techniques: Hill climbing techniques, Best First search, A* Search, Problem Reduction: AO* Search, Constraint Satisfaction, Means-End Analysis.

Game Playing: Game Tree, Searching procedure Minimax, alpha-beta pruning

Knowledge Representation: Knowledge Representation issues. Knowledge Representation using Predicate Logic: Unification, resolution.

Rule based Systems: Forward versus backward reasoning, conflict resolution. Structured Knowledge Representation: Semantic Nets, Frames, conceptual dependency, scripts.

Programming Languages: Fundamental and concepts of Programming languages like Prolog or Lisp. Reasoning: Handling uncertainty Non-Monotonic Reasoning, Probabilistic reasoning, use of certainty factors, fuzzy logic. Learning Concept of learning, learning automation, genetic algorithm, learning by inductions, neural nets.

Applications: Expert Systems: Architecture, Domain Knowledge, Knowledge Acquisition, Case Studies: MYCIN, RI, Natural language Processing: Syntactic, Semantic and Pragmatic Analysis, Robotics etc.

Suggested Books:

1. E. Rich and K. Knig, Artificial Intelligence, E. Rich and K. Knight, TMH, 2nd ed.(ISBN- 978-0070522633), February 28, 1991
2. N.J. Nilsson, Principles of AI, Narosa Publ. House, (ISBN: 978-81-85198-29-3), 17 April 1998
3. KM Fu ,Neural Networks in Computer Intelligence", McGraw Hill (ISBN- 978-0136042594), 1 February 1994.
4. George F. Luger , Artificial Intelligence: Structures and Strategies for Complex Problem Solving (5th Edition), 2005. Addison-Wesley. (ISBN: 978-8131723272)

ISY5303 Pattern analysis

Introduction to Pattern Analysis, Types of patterns, Feature, feature vectors, feature space and classifiers. Pattern recognition systems and its applications such as web based patterns.

Object Representation: Chain codes, Polygon Approximations, Signatures, Boundary segments, skeletons. Boundary Descriptors: Fourier Descriptor and Statistical Moments. Regional Descriptors: Topological descriptor, texture, moments of 2-D functions.

Maximum-likelihood and Bayesian parameter estimation: Maximum Likelihood estimation: Gaussian case, Maximum a Posteriori estimation, Bayesian estimation.

Bayesian decision theory: Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and Discriminant functions, Discrete features, Missing and noisy features.

Clustering, fundamentals of clustering, similarity/ dissimilarity, measures, clustering criteria, different distance functions: Bhattacharya Distance, scatter matrices, minimum cluster distance criteria, K-mean algorithm, K-medoids, DBSCAN, dataset visualization, unique clustering, no existence of clusters.

Neural networks as a feature extractor and classifier, single layer perceptron, multi-layer perceptron, training set, test set, generalization, normalization, and evaluation, evaluation Parameters-Accuracy, confusion matrix, Precision, Recall, ROC, F-measure, specificity, sensitivity.

Suggested Books:

1. Rafael C. Gonzalez, Richard Eugene Woods "Digital Image Processing" 3rd Edition, 2008
2. S.Theodoridis, K. Koutroumbas, "Pattern Recognition", IInd Edition, Elsevier, 2008
3. Richard O. Duda, Peter E. Hart, David G. Stork , "Pattern Classification", IInd edition, Wiley, 1973.

ISY5305 Business Intelligence and data warehousing

Introduction: Business Intelligence, Data Warehouses, Data mining, Pivot Tables, Relational Database review, Database Normalization, normal forms, DE normalization of tables, SQL, Data Warehousing fundamentals

Modelling the data warehouse: Data sources, operational data store, data marts, Characteristics and key figures , Creating InfoObjects, Building InfoCubes

Data Mining : Statistical techniques in data mining , Preparing data for mining, Association analysis, market basket analysis, Clustering , Classification, Regression, Decisions Trees, Building analytics applications, Mobile analytics.

Data Extraction, Transformation and Loading (ETL) in SAP BW Extraction from data sources such as SAP ERP, Flat file extraction, Defining and using Persistent staging areas PSA.

Introduction to Business Intelligence with Business Objects Analysis: Navigating in reports, Designing queries in the Query Designer, Using InfoProviders and InfoObjects for queries, Calculated and restricted key,

Query properties and navigation , Exceptions and Conditions.Front end visualization of business intelligence, Designing Dashboards, Designing reports, Business Objects Web Intelligence, Crystal Reports.

Suggested Books:

1. R. and Ross ,The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling Kimball, M.Second Edition. John Wiley & Sons, 2006.
2. Richard O. Duda, Peter E. Hart, David G. Stork , "Pattern Classification", IInd edition, Wiley, 1973
3. Christopher M. Bishop, "Pattern Recognition and Machine Learning", 15 February 2010

ISY5307 Edge computing

Introduction: What is IoT, Fog computing, Edge computing, Key techniques of edge computing, Importance of edge computing, Edge computing systems, Edge architecture.

Environment and Application: Cloud edge environment, Distributed Collaborative Execution on the Edges and Application on AMBER alert: Application design, Implementation details.

Challenges and Opportunities in Edge Computing: Programmability, Naming,Data abstraction, Service management, Privacy, Security, Application Distribution, Scheduling strategies,Business models, optimization metrics.

Existing Edge Computing Tools:Role of edge computing, virtualization, virtual machine, resourcemanagement, developing platforms for edge computing, edge analytics, development tools and platforms.

Suggested Books:

1. Jie Cao, Quan Zhang, Weisong Shi ,Edge Computing: A Primer, SpringerBriefs in Computer Science, 2018.
2. Gerardus Blokdyk , Edge Computing: Complete Self-assessment Guide, 2017.
3. Fadi Al-Turjman ,Edge computing: From Hype to Reality, Springer,2018.
4. Shijun Liu, BedirTekinerdogan, Mikio Aoyama, Liang-Jie Zhang, Edge Computing – EDGE 2018: Second International Conference, Held as Part of the Services Conference Federation, SCF 2018,

ISY5309 Financial data analytics

Introduction: The study of Language, Introduction to NLP, Regular Expression, Finite State Automata, Evaluating Language Understanding Systems, Different levels of Language Analysis, Representations and Understanding, Linguistic Background.

Financial reporting & Analysis: slicing & dicing, queries, reports, financial statement analysis, Banking analytics.

Data Visualization: Charts, Dashboards & Advanced Visualization Techniques in Accounting & Finance

Introduction to Audit Analytics, data mining and fraud, Computational Intelligence techniques such as logistic regression, neural networks, fuzzy logic and genetic algorithm for Credit Scoring, Cash flows & Fraud Detection

Descriptive Models for Accounting Decision Making, Predictive Accounting Models including Predictive Models with Non-Discrete Variables and Outcomes, Monte Carlo simulations and other stochastic modeling for budgeting, credit scoring, other accounting metrics with non-discrete inputs and outputs

Interpretation & Evaluation of results for Internal & External Reporting and Audit, Problem solving for complex accounting and business-related problems using appropriate data modeling tools.

Suggested Books:

Tsay, Ruey S. An introduction to analysis of financial data with R. John Wiley & Sons, 2014.

Alexander, Carol. Market models: A guide to financial data analysis. John Wiley & Sons, 2001.

Campbell, John Y., Andrew W. Lo, and Archie Craig MacKinlay. The econometrics of financial markets. Vol. 2. Princeton, NJ: princeton University press, 1997.

ISY5311 Foundation to computer security

Introduction: Basic concepts: threats, vulnerabilities, controls; risk; confidentiality, integrity, availability; security policies, security mechanisms; assurance; prevention, detection, deterrence.

Basic cryptography: Basic cryptographic terms, Historical background, Symmetric crypto primitives, Modes of operation, Cryptographic hash functions, Asymmetric crypto primitives.

Program security: Malicious code: viruses, Trojan horses, worms.Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation Software development controls, Testing techniques.

Trusted operating systems: Assurance; trust, Design principles, Evaluation criteria, Evaluation process

Database management systems security: Database integrity, Database secrecy, Inference control, Multilevel databases.

Network security: Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks.

Suggested Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice.", Prentice-Hall, 6 March 2013
2. Charles P. Pfleeger, "Security in Computing", Prentice Hall, February 5, 2015.
3. William R. Cheswick and Steven M. Bellovin, "Firewalls and Internet Security: Repelling the Wily Hacker", Addison-Wesley, March 6, 2003.

ISY5313 Information Audit

Types of Audit - general audits and specific audits; types of general audits and types of specific audits; continuous, periodical and balance sheet audits, concept and objectives of internal audit.

The Internal Auditor - qualifications for an internal auditor; need for independent functioning; relationship with the external auditor; code of ethics; qualities required in internal audit personnel; role of internal auditor as a management member.

Internal Controls on the Accounting Function -Internal control considerations, cash functions like Cash and bank; Salaries and employee benefits; Purchases and creditors; Sales and debtors; Inventories; Fixed assets and investments and other accounting activity.

Evaluation of Internal Control Systems - objectives of evaluation; steps in evaluation; techniques of evaluation; flowcharts and internal control questionnaires; internal control schemes.

Information Audit in an EDP Environment - audit planning in computerised environment; challenges for the auditor in an IT environment, internal audit practices in computerised systems, Computer assisted audit techniques (CAATs).

Suggested Books:

1. Gallegos, F., Manson D. P., Gonzales, C., Senft, S., Information Technology Control and Audit, Auerbach, 2004.
2. CISA Review Manual, ISACA publications. 2. Hunton, J.E., Bryant, S.M., and Bagranoff, N.A., Core Concepts of Information Technology Auditing, John Wiley & Sons, 2004.Champlain, J.J., Auditing Information Systems, John Wiley, 2003.

ISY5315 Information Integration and Data Analytics

Introduction to data analytics, Probability distributions, Model fitting, Descriptive statistics, Inferential Statistics through hypothesis tests

Supervised learning: Linear and logistic Regression, Lasso regression, ANNOVA, Linear and quadratic discriminant analysis, K-nearest neighbors, neural networks, deep learning, support vector machines, decision trees, random forest

Unsupervised learning: Introduction to Clustering mechanisms, K-means clustering, Hierarchical clustering, Unsupervised model fitting, Associative rule mining, Anomaly detection

Overview of information integration, integrated views and schema mapping, impact of increasing the number of data sources, data compression, record linking, data exchange, data fusion, data cleaning, source modeling, and information extraction

Retrieving data from Big data management systems, processing on Hadoop and Spark, Integration for Multi-channel customer analytics, Case studies, Data integration tools-Splunk and Datameer, Semantic web (RDF, OWL, SPARQL), linked data and services, mash-ups

Prescriptive Analytics: Creating data for analytics through designed experiments, creating data for analytics through Active learning, Creating data for analytics through Reinforcement learning.

Suggested Books:

1. Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009
2. Doan, AnHai, Alon Halevy, and Zachary Ives. Principles of data integration. Elsevier, 201 Montgomery, Douglas C., and George C. Runger. Applied statistics and probability for engineers John Wiley & Sons, 2010.

ISY5317 Linear Optimization

Introduction and Modeling with Linear Programming: Variants of the linear programming problem Examples of linear programming problems, Piecewise linear convex objective functions, Graphica representation and solution, Linear algebra background and notation, Algorithms and operatio counts.

Geometry of linear programming: Polyhedra and convex sets, Extreme points, vertices, and basi feasible solutions, Polyhedra in standard form, Degeneracy, Existence of extreme points, Optimalit of extreme points, Representation of bounded polyhedral, Projections of polyhedral: Fourier-Motzki elimination.

The Simplex Method: Optimality conditions, Development of the simplex method, Implementations of the simplex method, Anti-cycling: lexicography and Bland's rule, Finding an initial basic feasible solution, Column geometry and the simplex method, Computational efficiency of the simplex method.

Duality theory: The dual problem, The duality theorem, Optimal dual variables as marginal costs, Standard form problems and the dual simplex method, Farkas' lemma and linear inequalities, From separating hyperplanes to duality, Cones and extreme rays, Representation of polyhedral, General linear programming duality.

Sensitivity Analysis: Local sensitivity analysis, Global dependence on the right-hand side vector, The set of all dual optimal solutions, Global dependence on the cost vector, Parametric programming.

The art in linear optimization: Modelling languages for linear optimization, Linear optimization libraries and general observations, The fleet assignment problem, The air traffic flow management problem, The job shop scheduling problem.

Suggested Books:

1. Dimitris Bertsimas and John N. Tsitsiklis ,"Introduction to Linear Optimization", Athena Scientific (1 February 1997).
2. R. Fletcher, Practical Methods of Optimization, 2nd Edn., John Wiley, 1987.
3. D. G. Luenberger, Linear and Nonlinear Programming, 2nd Edn., Kluwer, 2003.
4. N. S. Kambo, Mathematical Programming Techniques, East West Press, 1997.
5. M. S. Bazarra, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, 2nd Edn., John Wiley, 1990. (also available as WSE (2003) edition).

SY5319 Management Information System

Introduction to Management Information Systems, History of MIS, Impact of MIS, Role and Importance, MIS Categories, Managers and Activities in IS, Types of Computers Used by Organizations in Setting up MIS, Hardware support for MIS, The Decision-Making Process, System Approach to Problem Solving, The Structure of Management Information System

Types of Management Systems, Concepts of Management Organization, Differences between planning and control information, Systems Analysis, Systems Design

MIS Planning and Development, Planning, development, Business Process Re – Engineering, Improving a process in BPR, Object Oriented methodology, Strategic Level Planning, Operational Level Planning, Economic and Behavior Theories.

Enterprise Resource Planning: Basics of ERP, Evolution of ERP, Enterprise Systems in Large Organizations, Benefits and Challenges of Enterprise Systems, Managing the E-enterprise, Organisation of Business in an E-enterprise, E-business, E-commerce, E-communication, E-collaboration

Trends in MIS: Introduction, Decision Support Systems (DSS), Artificial Intelligence (AI), Market Research Methods, Ratio Analysis for Financial Assessment, Management Science Models, Procedural Models, Project Planning and Control Models.

Suggested Books:

1. D.P. Goyal, "Management information systems", Macmillan India Ltd, 2014
2. Robert G. Murdick& Joel E. Ross & James R. Claggett, "Information Systems for Modern Management" PHI,2010
3. Gordon B. Davis & M.H. Olson, "Management Information Systems: Conceptual Foundation, structure & Development".2010

ISY5321 Multi agent system

Introduction to intelligent agents. Definition, Architectures interface agents, information agents, heterogeneous Multi-Agent Systems,distributed-intelligent-systems, Communication, Standards, Coordination, Negotiation, Distributed planning. Voting. Auctions. Coalition formation. Application of multi-agent systems to industrial problems.

Agent Design: Reasoning in Agents Definition of Reasoning. Automated Reasoning. Reasoning Paradigms. Symbolic Reasoning Agents. Deductive Reasoning Agents. Agent-Oriented Programming, Practical Reasoning. BDI Agents. BDI Agent Control Loop

Agent-Oriented-Methodologies Current trends in Software engineering. Agent-Oriented Software Engineering. Agent-Oriented Methodologies. The GAIA Methodology. The Prometheus Methodology

Social Design: Coordination and Social Models Coordination in MAS. Coordination Structures. Social Models for Coordination. Trust and Reputation Models. Organizational Models. Institutional Models.

Applications of Agent-Oriented Design. Agent-Oriented Design for 1) Electronic Negotiation Support, 2) Flexible Dynamic Web services, 3) Multi-robotic environments. Case studies for the practical assignments.

Suggested Books:

1. Michael Wooldridge (John Wiley and Sons), An Introduction to Multiagent Systems,first edition 2002, or second edition, 2009.
2. Luck, M., McBurney, P., Shehory, O., Willmott, S , Agent Technology: Computing as interaction. A Roadmap to Agent Based Computing, Willmott, S., 2005.

ISY5323 Privacy in location based services

Introduction – Evolution of Location Based Services – Application Areas of Location Based Services (LBS) – Application Taxonomy – LBS Privacy – LBS Markets and Customer Segments

Vehicle Tracking: Tracking Concepts, Components of Vehicle Tracking, Online and Offline Tracking. Alarms Used In Vehicle Tracking, Fleet Management – Vehicle Navigation: Navigation Concepts For Road, Waterways And Airways – Components Of Vehicle Navigation, File Formats Used For Navigation – Distress Call Management.

Mobile Device Eco-System: Mobile Applications, Business Model, and Privacy, Threats, Legal Protection of Location Data, user Perception of LBS: Overview on User Studies, User Attitude Towards LBS, Privacy Preferences of Users.

Design of Private Location-Based Services, Geo-Social Networks, Friend-Nearby Notification, POI Finder, Traffic Monitoring.

Quantification of Location Privacy, Obfuscation-based Protection Schemes: Hiding Events, Reducing Precision, Perturbation, Dummies.

Case Study: Develop A Real Time Case Study on Location Based Services Using the Above Concepts Learned and Submit A Working Application Along With the Presentation.

Suggested Books:

1. Jochen Schiller & Agnes Voisard" Location – Based Services" Morgan Kaufmann Publishers, 2004.
2. Syed A. Ahson& Mohammad Ilyas "Location-Based Services Handbook: Applications, Technologies, And Security – CRC Press, 2010

ISY5325 Probabilistic Graphical Models

Introduction, Graph theory, Probability Theory, Probability distributions, Bayes theorem, Bayesian Networks.

Learning Bayes nets, Undirected models, undirected graphical models and their temporal extensions.

Exact inference, MAP inference, message passing, sampling, Exponential families, Variational inference, Exact and approximate inference methods.

Parameter learning, Bayesian learning, Structured learning, estimation of parameters and the structure of graphical models.

Applications to computer vision, natural language processing, data mining, machine learning fields, decision-making under uncertainty.

Suggested Books:

1. Koller, Daphne, Nir Friedman, and Francis Bach. Probabilistic graphical models: principles and techniques. MIT press, 2009.
2. Andrew, Alex M. "INFORMATION THEORY, INFERENCE, AND LEARNING ALGORITHMS, by David JC MacKay, Cambridge University Press, Cambridge, 2003, hardback, xii+ 628 pp., ISBN 0-521-64298-1 (£ 30.00)-." Robotica 22, no. 3 (2004): 348-349.
3. Barber, David. Bayesian reasoning and machine learning. Cambridge University Press, 2012.

ISY5327 Software Engineering

Measurement in software engineering, scope of software metrics, Basics of Measurement: Models, Measurement Scales and Scale Types, Meaningfulness in Measurement.

Measuring External Product Attributes: Modeling Software Quality, Measuring aspects of quality, Goal Framework for Software Measurement. Classifying software measures, determining what to measure, applying the framework

Empirical Investigation & Data Collection: Four Principles of Investigation, planning formal experiments, defining data, collecting data.

Measuring Internal Product Attributes, Size and Structure: Aspects of Software Size, Length, Reuse, Functionality, Complexity, Types of Structural Measures, Modularity and information flow attributes, Object Oriented Metrics

Analyzing Software Measurement Data: Analyzing the results of experiments, Analysis Techniques, Overview of statistical tests.

Measurement and Management: Planning a measurement program, Measurement in practice, empirical research in software engineering

Suggested Books:

1. Roland Petrasch, "The Definition of, Software Quality': A Practical Approach", ISSRE, 1999.
2. J.D. Musa, A. Iannino, and K. Okumoto, Engineering and Managing Software with Reliability Measures, McGraw-Hill,1963.
3. Pressman, Scott , Software Engineering: A Practitioner's Approach (Sixth, International ed.), McGraw-Hill Education .2005

ISY5329 Theory of modern cryptography

Introduction: Need for security, Introduction to security attacks, services and mechanism, introduction to cryptography, Conventional Encryption: Conventional encryption model, classical encryption techniques.

Modern Block Ciphers: Block ciphers principals, Shannon's theory of confusion and diffusion, Fiestal structure, data encryption standard(DES), strength of DES, crypt analysis of DES, block cipher modes of operations, triple DES, IDEA encryption and decryption, strength of IDEA, key distribution.

Introduction to graph, ring and field, prime and relative prime numbers, modular arithmetic, Fermat's and Euler's theorem, primarily testing, Euclid's Algorithm, Chinese Remainder theorem, RSA algorithm,key management, Diffle-Hellman key exchange algorithm,

Message Authentication and Hash Function: Authentication requirements, authentication functions, message authentication code (MAC), hash functions, security of hash functions message digest algorithm, Public Key Infrastructure(PKI).

Authentication Applications: Kerberos and X.509, biometric authentication, electronic mail security-pretty good privacy (PGP), S/MIME.

IP Security: Architecture, Authentication header, Encapsulating security payloads, combining security associations, key management. Web Security: Secure Socket Layer(SSL) and transport layer security.

Suggested Books:

1. William Stallings, "Cryptography and Network Security: Principals and Practice", Prentice Hall, New Jersy.2002.
2. AtulKahate, "Cryptography and Network Security", TMH, 2017
3. Johannes A. Buchmann, "Introduction to Cryptography", Springer-Verlag,2004.
4. Behrouz A. Forouzan, "Cryptography and Network Security", TMH,2007.

Elective 3

ISY5201 SEMINAR

ISY5203 Latest Research in information technology

ISY5205 Optimization tools

Linear Programming Models, Prototype, Examples, Assumptions of Linear Programming, Additional Examples, Some Classic Case Studies. Graphical method, The Simplex Method: The Essence of the Simplex Method, Setting up the Simplex Method, The Algebra of the Simplex Method, The Simplex Method in Tabular Form, Tie Breaking in the Simplex Method, Adapting to Other Model Forms, Post optimality Analysis.

Dynamic programming, prototype example for Dynamic Programming, Characteristics of Dynamic Programming Problems, Deterministic Dynamic Programming, Probabilistic Dynamic Programming

Nonlinear Programming and Sample Applications, Graphical Illustration of Nonlinear Programming Problems, Types of Nonlinear Programming Problems, One-Variable Unconstrained Optimization, Multivariable Unconstrained Optimization.

Introduction to Evolutionary Computing Global Optimization, Components of an evolutionary algorithm, Evolution strategies, Fitness Functions, Learning Classifier systems, Parameter Control, Multi-modal Problems

Application to real world optimization problems Optimization examples from Machine Learning, Robotics, Image Processing and Computer Vision, Web and data mining, network traffic routing.

Suggested Books:

1. H.A.Taha – Operations Research, 8/e , Pearson Education , New Delhi, 2007.
2. Andries P. Engelbrech, John , Computational Intelligence", Second Edition, John Wiley & Sons, ISBN: 978-0-470-03561-0,2008
3. A.E Eiben and J.E. Smith , "Introduction to Evolutionary Computing", Springer, second edition,2007.
4. S. Hiller & G.J. Lieberman – Operations Research, 8th Edn, TMH, New Delhi – 2006,
5. David Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning". Addison-Wesley,1989

SEMESTER II

ISY502 High Performance Computing System

Cluster Computing:

Introduction to Cluster computing, Scalable Parallel Computer Architectures, Cluster Computer and its Architecture, Classifications, Components for clusters. Representative Cluster systems, Heterogeneous Clusters, Security, Resource Sharing, Locality, Dependability, Cluster Architectures, Detecting and Masking Faults, Recovering from Faults.

Load Sharing and Balancing: Evolution, Job and Resource Management Systems, State-of-the-Art in RMS and Job, Rigid Jobs with Process Migration, Fault Tolerance, Scheduling Problem for Network Computing, Algorithm-ISH, MCP and ETF, Task Granularity and Partitioning, Static and Dynamic Scheduling.

Cloud Computing:

Introduction to Cloud Computing, Types: Deployment and Service Models, Characteristics, Applications, Service-Level Agreement, Virtualization, High-Throughput Computing: Task Computing and Task-based Application Models, Market-Based Management of Clouds, Resource Allocation, Leases, Task Scheduling : RR, CLS and CMMS,Montage, Cloudlet, Virtual Machine and its Provisioning, Time and Space-shared Provisioning.

Data Access Optimization:

Balance Analysis and Light Speed Estimates, Storage Order, Case study: Jacobi Series and Dense Matrix Transpose, Algorithm Classifications and Optimizations, Sparse Matrix Vector Multiply

Suggested Books

1. Raj Kamal, Embedded System, TMH, 2004
2. Kennth J. Ayala, The 8051 Microcontroller, Thomson DelMar Learning, 2006
3 Deshmukh, Microcontrollers, TMH, 2006
4. Wayne Wolf, Computer as components, Harcourt India Pvt. Ltd, 2002
5. Philip A. Laplante,Real time System and Analysis, Wiley, 2006

ISY504 Computer Networks and Application

Introduction to Computer Networking Concepts: Layered Network Protocol Architectures; Personal, Local, Metropolitan and Wide Area Network

Data Link Layer and Logical Link Control (LLC) sub-layer: Framing; Error control including Bit-parity, CRC and Hamming Codes; Reliable transmission and Automatic Repeat Request (ARQ) protocols including Stop-and-Wait, Go-back-N, Selective Repeat.

Medium Access Control (MAC) sub-layer: Shared media systems; Bus, Star and Ring topologies; TDMA, FDMA, CSMA, CSMA/CD, Ethernet and IEEE 802.3; IEEE 802.11 including CSMA/CA protocols;

Network Layer: Internet Protocol (IP) suite; Hierarchical network architectures; IPv4 and IPv6 addressing and headers; Routing protocols including distance-vector and link-state approaches; Interior and Exterior Gateway Protocol concepts; Routing Algorithms including Dijkstra's algorithm and distributed Bellman-Ford algorithm; Example protocols: OSPF, RIP, BGP.

Transport Layer: Reliable end-to-end transmission protocols; UDP header; Details of TCP header and operation including options headers and congestion control; TCP variants such as Reno, Tahoe, Vegas, Compound and CUBIC.

Application Layer: Socket Interface and Socket programming.

Suggested Books

1. Kurose and Ross, "Computer Networking - A top-down approach", Seventh Edition, Pearson, 2017.
2. Andrew S. Tanenbaum, "Computer Networks", Fifth Edition, Pearson Education India, 2013.

3. Ying-Dar Liu, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", McGraw-Hill, 2011.

4. W. Richard Stevens, Bill Fenner and Andrew Rudoff, "Unix Network Programming", Volumes 1 and 2, Third Edition, Addison-Wesley Professional, 2003.

Elective 4

ISY5402 Advanced operating system

Types of Advanced Operating Systems. Architectures and design issues of Network operating system, DOS, Middleware, RTS, DBOS. Introduction to process, Concurrent processes, Critical Section problems, other synchronization problems

Scheduling: Issues in load distributing, Components of load distributing algorithms, Stability, Load distributing algorithms, Performance Comparison, Selecting a suitable load sharing Algorithm. Synchronization: Physical and logical clocks. Distributed Mutual Exclusion: Introduction, Classification of Mutual Exclusion algorithms, Mutual Exclusion Algorithms. Distributed Deadlock.

Agreement Protocol: System Model, Classification, Solution to Byzantine Agreement Problem. Fault Recovery: Concepts, Classification of failures, Backward error recovery, Recovery in concurrent Systems, Consistent Check Points, Synchronous and Asynchronous check pointing and recovery.

Types of Real time tasks, Timing Constraints, Modeling Timing Constraints. Task Scheduling: Types of tasks and their characteristics, Task Scheduling, Clock driven Scheduling, Hybrid Schedulers.

Concurrency control: Database systems, Concurrency control model of database systems, Problem of Concurrency Control, serializability theory, Distributed Database Systems.Concurrency Control Algorithms Basic synchronization Algorithms, Lock based, Concurrency Control Algorithms

Suggested Books:

1. Mukesh Singhal, Niranjan G.Shivaratri, "Advanced concepts in operating systems: Distributed, Database and multiprocessor operating systems" MC Graw Hill education,2011.

2. Rajib Mall, "Real-Time Systems: Theory and Practice", Pearson education,2006.

3. Andrew S.Tanenbaum, "Modern Systems Principles and Paradigms". PHI.

4. Pradeep K.Sinha, "Distributed Operating System-Concepts and design", PHI,2003.

5. Andrew S.Tanenbaum, "Distributed Operating System", Pearson Education. 4. Jane W. S. Liu, "Real Time Systems", Pearson education,2006.

ISY5404 Cloud computing and virtualization

Overview: – A short history Client – Server Computing, Peer-to-Peer Computing, Distributed Computing, Collaborative Computing, Cluster Computing, Grid Computing, Cloud Computing, Functioning of Cloud Computing, Cloud Architecture, Cloud Storage, Cloud Services.

Cloud Computing Service Models and Development Models:- Objectives, Service Modelling, Infrastructure Services, Platform Services, Software Services - Software as service modes-Private Cloud, Community Cloud, Public Cloud, Hybrid Cloud.

Migrating to the Cloud and Virtualization: - Objectives, Cloud Services for individuals- Available Services - Skytap Solution, Cloud Services Aimed at the mid – market, Enterprise Class Cloud Offerings- Migration- Applications needed for migration - Moving existing data to cloud- Using the Wave approach.

Data Management and Information Storage in Cloud Computing:- Introduction- Objectives, Data Security- Data Location- Data Control- Securing data for transport, Scalability and Cloud Services- Large Scale Data Processing.

Cloud Security:- Security issues associated with the cloud, Cloud security controls, Dimensions of cloud security, Security and privacy, Cloud Vulnerability and Penetration Testing, Data security, Confidentiality, Encryption.

Suggested Books:

1. Rajkumar Buyya ,Cloud Computing: Principles and Paradigms, Wiley; 1 edition (2013).
2. Kai Hwang Professor, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Morgan Kaufmann (22 November 2011).
3. Thomas Erl. "Cloud Computing: Concepts, Technology & Architecture", PHI; 1 edition (10 May 2013)

ISY5406 Foundation of information theory and coding

Introduction to Probability, Sample space and events, The axioms of probability,Conditional Probability and Independence, Baye's theorem. Random variables, discrete probability distribution, discrete functions for random and discrete random variables.

Uncertainty and Information, Shannon Entropy, Joint and conditional Entropies, Mutual Information, Uniquely decipherable and Instantaneous codes, Noiseless coding problem. Source coding Theorem, Block coding, construction of Optimal codes,

Discrete memoryless channel, channel capacity BSC and other channels, the channel coding theorem, application to BSC.

Information measure for continuous ensembles capacity of AWGN channel. Error control coding. Types of codes, error and error control strategies, Linear block codes, syndrome and error detection, Minimum distance, Error detecting and correcting capabilities of a block code, Syndrome decoding, Hamming codes

Cyclic codes, Generator and parity, encoding, syndrome computation, error detection and decoding. BCH codes, decoding of the BCH codes Introduction to RS codes.

Blind Deconvolution Using Convex Programming, Asynchronous code division random access using convex optimization.

Suggested Books:

1. R Ash , Information Theory, Dover Science Publications,1990.
2. Cover and Thomas , Element of Information Theory , John Wiley & Sons,2006.
3. Shulin& Daniel J. Costello Jr , Error Control coding: Fundamental & Applicatio, Prentice Hall, 1948
4. C. E. SHANNON, A Mathematical Theory of Communication, 1948 The Bell System Technical Journal,1948.

ISY5408 Internet security and privacy

Introduction: Basic concepts: threats, vulnerabilities, controls; risk; confidentiality, integrity, availability; security policies, security mechanisms; assurance; prevention, detection, deterrence.

Basic cryptography: Basic cryptographic terms, Historical background, Symmetric crypto primitives, Modes of operation, Cryptographic hash functions, Asymmetric crypto primitives.

Program security: Malicious code: viruses, Trojan horses, worms.Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation, Software development controls , Testing techniques

Trusted operating systems: Assurance; trust, Design principles, Evaluation criteria, Evaluation process.

Database management systems security: Database integrity, Database secrecy, Inference control, Multilevel databases.

Network security: Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection.

Suggested Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice.", Prentice-Hall,2006.
2. Charles P. Pfleeger, "Security in Computing", Prentice Hall,2019.
3. William R. Cheswick and Steven M. Bellovin, "Firewalls and Internet Security: Repelling the Wily Hacker", Addison-Wesley,2003.
4. Charlie Kaufman, Radia Perlman and Mike Spencer, "Network Security: Private Communication in a Public World", Prentice Hall, March 6, 2003.

ISY5410 Machine learning

Introduction: Linear Algebra, Probability Theory, Introduction to Bayesian Methods, Parametric Methods, Discriminant Functions.

Supervised Learning: Linear Regression models, classification, Linear discriminant analysis, Probably Approximately Correct (PAC) Learning, Learning Multiple Classes, Model Selection and Generalization, Support vector machine, Decision trees, Nearest neighbors, neural networks.

Unsupervised Learning: Clustering, Mixture Models, Latent Variables, Expectation-Maximization, Feature selection, Dimensionality Reduction, Factor/Component Analysis, Linear Discriminant Analysis.

Genetic Algorithms: Motivation, Genetic operators, Fitness function, Models of Evolution and Learning, Fuzzy Logic: Fuzzy sets and operations, Membership function, Classical sets, angular fuzzy sets.

Reinforcement Learning: Introduction, The learning task, Q learning, Non-deterministic rewards and actions, Relationship to dynamic programming, Model-Based Learning.

Recent applications: Speech recognition, computer vision, natural language processing, face recognition.

Suggested Books:

1. Alpaydin, E, Introduction to Machine Learning, MIT Press, 2004
2. Tom Mitchell , Machine Learning, McGraw Hill, 1997
3. David Barber , Machine Learning: A probabilistic approach, 2006.
4. Charlie Kaufman, Radia Perlman and Mike Spencer, "Network Security: Private Communication in a Public World", Prentice Hall,2008.

ISY5412 Mobile application

Introduction to Android: Native Android Application; SDK Features; Introduction to Open Handset Alliance; Development Framework; Application Fundamentals; Device Compatibility; System permissions.

User Interface and Application Components: Basic UI Design; Fragments; Widget Toolbox; Creating New View; Introduction to Intents; Intent Filters and broadcast Receivers; Activities; Services; Content Providers; Application Widgets; Processes and Threads.

Files and Database Handling: Saving Application Data; Shared Preferences; Preference Framework and Activity; Static File as Resource; File System; Introduction to SQLite Database; Querying SQLite; Storage options; Data backup

User Experience Enhancement: Action Bar; Menus and Action Bar Items; Settings; Dialogs; Customizing Toast; Notifications; Search; Drag and Drop

Multimedia, Wireless Connectivity and Telephony: Audio and Video Handling; Manipulating Raw Audio; Sound Effects; Camera Programming; Video Recording;

Managing Wireless Connectivity : Wi-Fi, Bluetooth, Near Field Communication; Hardware Support for Telephony; Telephony Management; SMS and MMS.

Suggested Books:

1. Reto Meier, "Professional Android 4 Application Development", Wrox, 2012
2. Matt Gifford, "PhoneGap Mobile Application Development Cookbook", PACKT, 2012
3. Adrian Kosmaczewski, "Mobile JavaScript Application Development", O'RELLY, 2012

ISY5414 Semantic web

Semantic Web Introduction: fundamental of semantic web, Examples of semantic web, Semantic web technologies, layered approach Web Intelligence Thinking and Intelligent Web Applications, The World Wide Web, Limitations of Today's Web.

Structured web documents in XML: The XML language, Structuring, Namespaces, Querying and Addressing XML documents. Knowledge Representation for the Semantic Web Ontologies and their role in the semantic web, Ontologies Languages for the web, UML, XML/XML Schema

Web Ontology Engineering: Introduction, OWL language, Examples, OWL in OWL, Future extensions, Ontology Engineering, Ontology Engineering, Constructing Ontology, Ontology Development Tools, Ontology Methods.

Applications: Semantic Search, e-learning, Semantic Bioinformatics, Knowledge Base, XML Based

Web Services, Creating an OWL-S Ontology for Web Services, Semantic Search Technology, Web Search Agents and Semantic Methods.

Describing Web Resources: Introduction, RDF, RDF Schema, RDF: XML-Based Syntax, RDF serialization, syntax and language, Direct Inference System, Querying RQL, A query language for RDF: SPARQL

Suggested Books:

1. Berners Lee, Godel and Turing ,Thinking on the Web , Wiley inter science, 2008.
2. Grigoris Antoniou and Frank Van Hermelen , A Semantic web Primer, MIT Press,2008.
3. John Davies (Editor), Rudi Studer (Co-Editor), Paul Warren (Co-Editor) ,Semantic Web Technologies, Trends and Research in Ontology Based Systems,2006.

ISY5416 Smart sensing for internet of things

INTRODUCTION& CONCEPTS: Introduction to Internet of Things, Definitions and Characteristics of IoT, Physical Design of IoT, Things in IoT, IoT Protocols, Logical Design of IoT, IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies, Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols.

IoT and M2M, Introduction, M2M, Difference between IoT and M2M, SDN and NFV for IoT, Software Defined Networking, Network Function Virtualization, IoT Platform Design Methodology, Introduction, IoT Design Methodology.

IoT System Logocal Design Using Python, Introduction, Installing Python, Python Data Types and Data Structures, Control Flow, Functions, Modules, Packages, File Handling, Date Time applications, Classes, Python Packages of Interest for IoT.IoT Physical Devices and End Points.

Data Analytics for IoT; Introduction AppacheHadoop, using HadoopMapReduce for Batch Data Analysis, Apache oozie, Apache Spark, Apache Storm, using Apache Storm for Real-time Data Analysis.

Ethics: Characterizing the IoT, Privacy, Control , Distributing Control and Crowd Sourcing.

Suggested Books:

1. Raj Kamal ,"INTERNET OF THINGS" , McGraw-Hill,2017.
2. Timothy Chou ,"Precision - Internet Of Things", McGraw-Hill,2017.
3. Rajkumar Buyya,Amir Vahid Dastjerdi , "Internet of Things Principles and Paradigms, Morgan Kaufmann (10 May 2016)".

Elective 5

ISY5302 Minor Project

ISY5304 Advanced computer vision

Image Formation Models: Monocular imaging system, Orthographic & Perspective Projection, Camera models and Camera calibration, Sources, shadows and shading

Image Processing: Image representation, feature extraction and matching, Image filters, Edge detection, Image texture analysis, Clustering, Model Fitting

Motion Estimation: Regularization theory, Optical computation, Multi-view scene processing, depth recovery from Stereo Vision, Motion estimation, Structure from motion

Shape Representation and Segmentation: Deformable curves and surfaces, Snakes and active contours, Level set representations, Fourier and wavelet descriptors, Medial representations, Multiresolution analysis

Object recognition: Hough transforms and other simple object recognition methods, Shape correspondence and shape matching, Principal component analysis, Tracking with linear dynamical models

Object detection and tracking: Tracking with linear dynamical models, Optical flow estimation, Object tracking using deep neural networks.

Suggested Books:

1. D. Forsyth and J. Ponce ,Computer Vision - A modern approach, Prentice Hall,2012.
2. Linda Shapiro and George Stockman ,Computer Vision, Prentice-Hall, 2001.
3. Szeliski, Richard. Computer vision: algorithms and applications. Springer Science & Business Media, 2010.
4. E. Trucco and A. Verri , Introductory Techniques for 3D Computer Vision, Publisher: PHI 4. COMPUTER SECURITY.

ISY5306 Ad-Hoc wireless network

Ad-hoc Wireless Networks Introduction and Issues, Mobile Ad-Hoc Networking with a View of 4G Wireless: Imperatives and Challenges, IEEE 802.11 in Ad Hoc Networks: Protocols, Performance and Open Issues; MAC Protocols for Ad-hoc Wireless Networks: Introduction,Contention-Based Protocols.

Routing Protocols for Ad-hoc Wireless Networks: Introduction, Issues in Designing a Routing Protocol for Ad-hoc Wireless Networks; Classification of Routing Protocols; Table Driven Routing Protocols; On-Demand Routing Protocols, Hybrid Routing Protocols.

Multicast Routing in Ad-hoc Wireless Networks Introduction, Issues in Designing a Multicast Routing Protocol, Operation of Multicast Routing Protocols.

Transport Layer and Security Protocols for Ad-hoc Networks: Introduction, Issues in Designing a Transport Layer Protocol; Design Goals of a Transport Layer Protocol; Classification of Transport Layer Solutions; TCP over Transport Layer Solutions.

Quality of Service and Energy Management in Ad-hoc Wireless Networks: Introduction, Issues and Challenges in Providing QoS in Ad-hoc Wireless Networks, Classification of QoS Solutions, MAC Layer Solutions and Network Layer Solutions.

Suggested Books:

1. C. Siva Ram Murthy & B. S. Manoj: Ad-hoc Wireless Networks, 2nd Edition, Pearson Education, 2011
2. Ozan K. Tonguz and Gianguigi Ferrari: Ad-hoc Wireless Networks, John Wiley, 2007.

3. Xiuzhen Cheng, Xiao Hung, Ding-Zhu Du: Ad-hoc Wireless Networking, Kluwer Academic Publishers, 2004.

4. C.K. Toh: Ad-hoc Mobile Wireless Networks- Protocols and Systems, Pearson Education, 2002

ISY5308 Advance Topic in Mobile Computing

MOBILE COMMUNICATIONS: AN OVERVIEW

Mobile communication-Mobile Computing-Mobile Computing Architecture-Mobile devices-Mobile System Networks – Data dissemination – Mobile management- security. MOBILE DEVICES AND SYSTEMS.

GSM AND SIMILAR ARCHITECTURES:

GSM – services and architectures – Radio interfaces – Protocols – Localization – Calling – Handover – Security – New data services – General packet radio service- High speed circuit switched data – DECT. WIRELESS MEDIUM ACCESS CONTROL BASED COMMUNICATION-Medium Access Control

MOBILE IP NETWORK LAYER AND MOBILE TRANSPORT LAYER:

IP and mobile Network layers – Packet Delivery and Handover Management – Location management – Registration – Tunnelling and Encapsulation - Route Optimization - Dynamic Host Configuration Protocol. Conventional TCP/IP Transport Layer Protocols – Indirect TCP – Snooping TCP – Mobile TCP – Other methods of mobile TCP – layer transmission – TCP over 2.5G/3G Mobile networks.

SERVER AND MANAGEMENT:

Mobile agent – Application server – Gateways – Portals -Service Discovery – Device management – Mobile file systems-Security.

MOBILE AD HOC AND WIRELESS SENSOR NETWORKS-Introduction to mobile Ad hoc network – MANET –Wireless Sensor Networks –Applications.

Suggested Books:

1. Raj Kamal, "Mobile Computing",Oxford Higher education, Second Edition, 2007

2. Jochen Schiller, "Mobile Communications", Addison-Wesley, 2nd Edition. 2004

3. LotherMerk, Martin.S.Nicklaus and Thomas Stober, "Principle of Mobile Computing",Second Edition, Springer, 2003.

4. William C.Y.Lee, "Mobile Communication Design Fundamentals", John Wiley,1993.

ISY5310 Applied cryptography

Number Theory Basics: Modular arithmetic, primes, GCD and Chinese reminder theorems.

Block Ciphers: DES, AES; ECB, CBC, OFB, CFB, CTR and GCM modes, Double and triple encryptions.

Public Key Cryptography: RSA, ElGamal, Diffe-Hellman Key exchange, practical digital signatures. ECC.

Hash Functions: oneway, collision resistant, preimage resistant HASH functions, Real-world examples.

Message Authentication Codes: MAC from Hash functions, MAC from block ciphers.

Side Channel Analysis: Power / timing analysis of crypto-implementations

Applications: Key Establishment Protocols, Blockchains, etc.

Suggested Books:

1. William Stallings ,CNS: "Cryptography and Network Security: Principles and Practice" (6th Edition),2014.
2. Menezes, van Oorschot, and Vanstone , HAC: "The Handbook of Applied Cryptography",1996.
3. IdCrypto: C. Youngblood, "An Introduction to Identity-Based Cryptography," CSEP 590TU, 2005.
4. AnCom: Ren J and Wu J. Survey on Anonymous Communications in Computer Networks. Computer Communications. 2010, 33(4): 420–431.

ISY5312 Collaborative filtering

Introduction to collaborative filtering: Collaborative Filtering-Based Recommendations, Measuring Similarity, Cosine Similarity, Types of filtering: Model-based Collaborative Filtering, Memory based, hybrid Context-aware collaborative filtering, Neighbourhood-based approach: selecting neighbourhood, the sparsity problem. User-Based Collaborative Filtering, Item-Based Collaborative Filtering

Application on social web: Problems, Challenges: Data sparsity, Scalability, Synonyms, Gray sheep, Shilling attacks, Diversity and the long tail. Evaluation of recommendation system, case study.

Suggested Books:

1. Jun Wang ,Collaborative Filtering and Recommender Systems, Wiley, 2017, ISBN 0470547987, 9780470547984,2017.
2. SuXiaoyuan , Collaborative Filtering , LAP Lambert Academic Publishing, ISBN: 9783659429095, 3659429090, 2013.
3. Ekstrand Michael D ,Collaborative Filtering Recommender Systems, now publishers Inc, ISBN: 9781601984425, 1601984421, 2011.

ISY5314 Cyber security and law

The World Wide Web, Web Centric Business, E Business Architecture, Models of E Business, E Commerce, Threats to virtual world. Cyber Crimes& social media, Cyber Squatting, Cyber Espionage, Cyber Warfare, Cyber Terrorism

Computer ethics, moral and legal issues, descriptive and normative claims, Professional Ethics, code of ethics and professional conduct. Privacy, Computers and privacy issue.

Web Servers and Browsers, HTTP, Cookies, Caching, Plug-in, ActiveX, Java, JavaScript, Secure Socket Layer (SSL), Secure Electronic Transaction (SET). E-mail Risks, Spam, E-mail Protocols, Simple Mail Transfer Protocol (SMTP), Post office Protocol (POP), Internet Access Message protocol (ICMP). Secured Mail Protocols.

Copyrights, Jurisdiction Issues and Copyright Infringement, Multimedia and Copyright issues, WIPO, Intellectual Property Rights, Understanding Patents, Understanding Trademarks, Trademarks in Internet, Domain name registration, Software Piracy, Legal Issues in Cyber Contracts, Authorship,

Document Forgery.

Indian IT ACT, Adjudication under Indian IT ACT, IT Service Management Concept, IT Audit standards, System audit, Information security audit, ISMS, SoA (Statement of Applicability), BCP (Business Continuity Plan), DR (Disaster Recovery), RA (Risk Analysis/Assessment).

Suggested Books:

1. RaefMeeuwisse , Cyber security for Beginners, Cyber Simplicity Ltd; 2nd Revised edition edition (14 March 2017).
2. Advocat Prashant Mali ,Cyber Law & Cyber Crimes; Snow White publications, Mumbai,2012.
3. Yuri by Yuri Diogenes, Cyber security - Attack and Defence Strategies, Packt Publishing; 1 edition (30 January 2018).

ISY5316 Deep learning

Introduction: Basics of deep learning, Importance of deep learning, Feature engineering, Overview of deep learning framework.

Machine Learning Basics: Supervised learning algorithms, Hyper parameters and validation sets, overfitting, under fitting, Unsupervised learning algorithms, Stochastic Gradient Descent, Challenges motivating Deep Learning.

Deep feed forward network: Artificial Neural Network, activation function, multi-layer neural network, Training Neural Network: Risk minimization, loss function, backpropagation, regularization, model selection, and optimization, Data Augmentation, Dropout.

Convolutional Networks (CNN): Motivation, The Convolution Operation, Pooling, Structured outputs, Kernels.

Recurrent and Recursive Nets: Recurrent Neural Networks (RNN) , Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, Long-Term Dependencies, Long-Short Term Memory, Gated RNNs.

Applications: Large scale deep learning, Computer vision, Speech Recognition, Natural Language Processing, Other applications, Deep Learning Tools and Libraries: Caffe, Theano, Keras..

Suggested Books:

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Python Deep Learning, by Valentino Zocca, GianmarioSpacagna, Daniel Slater, and Peter Roelants, Packt Publishing Ltd, 2017.
3. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.

ISY5318 Digital watermarking and Steganalysis

Introduction: Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Theoretic Foundations of Steganography

Applications and Properties: Applications of Watermarking, Applications of Steganography, Properties of Watermarking Systems, Evaluating Watermarking Systems, Properties of Steganographic and Steganalysis Systems, Evaluating and Testing Steganographic Systems.

Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modeling Watermark Detection by Correlation, Basic Message Coding: Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multisymbol Watermarks.

Watermarking with Side Information: Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes, Robust Watermarking: Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions.

Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks, Content Authentication: Exact Authentication, Selective Authentication, Localization, Restoration

Steganalysis: Steganalysis Scenarios, Some Significant Steganalysis Algorithms, Case studies

Suggested Books:

1. Ingemar Cox Matthew Miller Jeffrey Bloom Jessica Fridrich Ton Kalker, "Digital Watermarking and Steganography, Morgan Kaufmann 13th November 2007
2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom , Digital Watermarking principles, Morgan Kaufmann (June 1, 2011)
3. Ingemar Cox Matthew Miller Jeffrey Bloom Mathew Miller , Digital Watermarking, Morgan Kaufmann (June 1, 2011)

ISY5320 Distributed Data Mining

Introduction and Incremental & Stream Data Mining:- Fundamentals of data mining, Data Mining Functionalities, Classification of Data Mining systems, Major issues in Data Mining Incremental Algorithms for Data Mining, Characteristics of Streaming Data, Issues and Challenges, Streaming Data Mining Algorithms, Any time stream Mining.

Distributed computing solutions for data mining:-MapReduce/Hadoop and Spark, Cluster Computing

Mining Complex Structures:-Algorithmic Development Issues, Mining trees, Tree Model Guided Framework, TMG framework for mining ordered & unordered subtrees, Tree Mining Applications, Mining Graphs, Approaches to graph mining

Sequence Mining: - Characteristics of Sequence Data, Problem Modeling, Sequential Pattern Discovery, Timing Constraints, Applications in Bioinformatics.

Web Search: - Crawling & Indexing, Hyperlink Analysis, Page Rank algorithm, Web Search and Information Retrieval.

Suggested Books:

1. Hadzic F., Tan H. & Dillon T. S. "Mining data with Complex Structures" Springer, 2011
2. Yates R. B. and Neto B. R. "Modern Information Retrieval" Pearson Education, 2005
3. Tan P. N., Steinbach M & Kumar V. "Introduction to Data Mining" Pearson Education, 2006.
4. Han J. &Kamber M., "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers, Second Edition, 2006.

ISY5322 Graph Theory

Graphs, Konisberg-problem,isomorphism, subgraphs, matrix representations, degree, operations on graphs, degree sequences, Walks, trails, paths, connected graphs, distance, weighted graphs, connectivity

Dijkstra's shortest path algorithm, Floyd-Warshall shortest path algorithm, graphs, Hamiltonian paths and circuits, operations on graphs.

Trees, number of trees, minimum spanning trees, distance and centers in a tree, rooted and binary trees, fundamental circuits, cut sets and cut vertices.

Connectivity and separability, edge connectivity, vertex connectivity, network flows, planar and dual graphs, geometric dual .

Matrix representation of graphs, incidence matrix, circuit matrix, cut-set matrix, path matrix, application to a switching network, applications of graphs

Suggested Books:

1. Nersing Deo ,Graph theory with applications to engineering and computer science", PHI,1979.
2. D.B. West. Introduction to Graph Theory. Prentice Hall of India, 2005.
3. R.B. Bapat ,"Introduction to Graph Theory (5th edition)" by Robin Wilson, Person Education Limited 2010.

ISY5324 Network anonymity and privacy

Anonymity and Privacy, and why it matters, Networking basics, various network challenges, cryptography, firewalls, web authentication, user tracking

Corporate Network Security Policies, threats and controls, Firewall: Technologies, Stateful and stateless firewall, Transparent Proxy and Protocol or Application Gateway, Linux-based Firewall: ip chains&ip tables, Internet Services against firewall.

Virtual Private Network (VPN): Concepts and technologies, IPSec and Free S/WAN, VPN with Firewall, Intrusion Detection System(IDS): Concepts, Network-based and Host based IDS, tripwire or Snort or Port Sentry setup and management, onion routing, anonymous browsing, P3P

Historical network anonymity and privacy protocols ndash; MIXes and MIXnets, various theoretical and practical attack strategies against high and low-latency anonymity networks, practical traffic analysis against modern anonymity systems like Tor, Freenet, GNUnet, JAP.

Side-channel attacks, covert channel communications, pseudonymity and privacy, Anonymous P2P communication systems (e.g. Oneswarm), traffic analysis against anonymous VoIP communications. Definition and value of privacy, Conceptual frameworks for reasoning about privacy.

Suggested Readings:

1. Matthew Bailey , Complete Guide to Internet Privacy, Anonymity & Security,2014.
2. Kun Peng , "Anonymous Communication Networks: Protecting Privacy on the Web,2014
3. William Stallings, "Cryptography and Network Security: Principles and Practice.", Prentice-Hall,2002.

ISY5326 Topics in computer security

Overview of Network Security, Security services, attacks, Security Issues in TCP/IP suite- Sniffing, spoofing, buffer overflow, ARP poisoning, ICMP Exploits, IP address spoofing, IP fragment attack, routing exploits, UDP exploits, TCP exploits.

Authentication requirements, Authentication functions - Message Authentication Codes - Hash Functions - Security of Hash Functions and MACs - MD5 message Digest algorithm - Secure Hash Algorithm - RIPEMD - HMAC Digital Signatures, Authentication Protocols-Kerberos, X.509.

IP Security-AH and ESP, SSL/TLS, SSH, Web Security-HTTPS, DNS Security, Electronic Mail Security (PGP, S/MIME).

Intruders, Viruses, Worms, Trojan horses, Distributed Denial-Of-Service (DDoS), Firewalls, IDS, Honey nets, Honey pots.

Introduction to wireless network security, Risks and Threats of Wireless networks, Wireless LAN Security (WEP, WPA).

Network security: Network threats: eavesdropping, spoofing, modification, denial of service attacks of Introduction to network security techniques: firewalls, virtual private networks.

Suggested Books

1. William Stallings, "Cryptography and Network Security: Principles and Practice.", Prentice-Hall,2006.
2. Charles P. Pfleeger, "Security in Computing", Prentice Hall,2015.
3. Matthew Bailey ,Complete Guide to Internet Privacy, Anonymity & Security,2014.

Elective 6

ISY5202 Research problem formulation

Introduction, thinking skills: Problem solving, creativity, problem finding and formulation, Experimental and Modeling skills, Communication skills - oral and written, Management skills: Stress and time management, Interpersonal relations, professional ethics, Publishing and patenting.

Suggested Readings:

1. John W. Creswel ,Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (Paperback), 2013
2. Uwe Flick, Introducing Research Methodology: A Beginner's Guide to Doing a Research Project Second Edition,2017.
3. Ranjit Kumar , Research Methodology: A Step-by-Step Guide for Beginners Fourth Edition ,2014.

ISY5204 Laboratory on advanced topics

I: Advanced Programming with Data Science:

Python 3.5, The NumPy package for scientific computing, The pandas data analysis library, including reading and writing of CSV files, The Jupyter and PyDev development environments, The Matplotlib 2D plotting library, Understanding the shell, Using Git and GitHub, Best-practice software engineering techniques.

Suggested Readings:

1. Wes McKinny, O'Reilly Media ,Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython, 2012. ISBN 978-1-4493-1979-3.
2. William E. Shotts, The Linux Command Line: A Complete Introduction , Jr., No Starch Press, 2012. ISBN 978-1-5932-7389
3. Mark Lutz, O'Reilly Media , Learning Python, 5th Edition, 2013. ISBN 978-1-4493-5573-9.

SEMESTER III

Elective 7

ISY6401 Biometrics Systems

Introduction to Bio-Metric System: Development of biometric authentication. Basic terms, biometric data, biometric characteristics, biometric features, biometric templates and references. Expected properties of biometric identifiers.

Fingerprint recognition: Fingerprint capture, sensor types, latent fingerprints. Fingerprint image pre-processing, segmentation, binary and skeletal images. Fingerprint singularities.

Iris recognition: Eye and iris morphogenesis, genetic penetrance. Principles of iris image capture, iris sensors. Iris image preprocessing, segmentation, formatting and filtering.

Face recognition: Face detection in still images and sequences. Face features. Face space, principal component analysis and its application, Eigen faces, linear discriminant analysis and its application, Fisher faces. Face recognition methods.

Recognition of handwritten signatures: Signature capture, off-line (scanned) and on-line (captured by tablets) signatures. Signature as a multidimensional curve, two- and multi-dimensional analyses. Signature features, hidden and visible features.

Security of biometrics system: Secure transfer of biometric data. Merging biometrics and cryptography, template protection. Merging biometrics and steganography..

Suggested Books:

1. Jain, A.K., Ross, A., Nandakumar, K. Introduction to Biometrics. Edition 2011.
2. Maltoni, D., Maio, D., Jain, A.K., Prabhakar, S., Handbook of Fingerprint Recognition. Second edition 2009.
3. Marcel, S., Nixon, M.S., Li, S.Z., Handbook of Biometric Anti-Spoofing: Trusted Biometrics under Spoofing Attacks (Advances in Computer Vision and Pattern Recognition). Edition 2014.

ISY6403 Natural Language Processing

Introduction: The study of Language, Introduction to NLP, Regular Expression, Finite State Automata, Evaluating Language Understanding Systems, Different levels of Language Analysis,

Grammars and Parsing: Top-Down and Bottom-Up Parsers, Transition Network Grammars, Top-Down Chart Parsing, Feature Systems and Augmented Grammars, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.

Grammars for Natural Language: Auxiliary Verbs and Verb Phrases, Movement Phenomenon in Language, Handling questions in Context Free Grammars, Hold mechanisms in ATNs.

Ambiguity Resolution: Statistical Methods, Probabilistic Language Processing, Estimating Probabilities, Part-of-Speech tagging, Obtaining Lexical Probabilities,Probabilistic Context-Free Grammars, Dependency Parsing, Best First Parsing, Semantics and Logical Form, Word senses and Ambiguity, Encoding Ambiguity in Logical Form.

Advanced Features and Syntax, Features and Unification: Feature structures – Unification of feature structures – Features structures in the grammar – Implementing unification – Parsing with unification constraints – Types and Inheritance.

Application of NLP: Intelligent Work Processors, Machine Translation, User Interfaces, Man-Machine Interfaces, Natural language Querying Tutoring and Authoring Systems.

Suggested Books:

1. JamesAllen, Natural Language Understanding, 2/e, Pearson Education (ISBN 13: 9788131708958), 2003
2. D. Jurafsky, J. H. Martin, Speech and Language Processing, Pearson Education,(ISBN-13: 978-8131716724), 2008.
3. Manning and Schutze ,Foundation of Statistical Natural Language Processing, (ISBN-13: 978-0262133609), 1998.

ISY6405 Network security

Introduction: Basic concepts: threats, vulnerabilities, controls; risk; confidentiality, integrity, availability; security policies, security mechanisms; assurance; prevention, detection, deterrence.

Basic cryptography: Basic cryptographic terms, Historical background, Symmetric crypto primitives, Modes of operation, Cryptographic hash functions, Asymmetric crypto primitives.

Program security: Malicious code: viruses, Trojan horses, worms. Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation Software development controls, Testing techniques

Trusted operating systems: Assurance; trust, Design principles, Evaluation criteria, Evaluation process.

Database management systems security: Database integrity, Database secrecy, Inference control, Multilevel databases.

Network security: Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection.

Suggested Books:

1. Bruce Schneier, "Applied Cryptography: Protocols, algorithms and source code in C", John Wiley & Sons Inc,2015.
2. William Stallings, "Cryptography and Network Security", Prentice Hall,2006.
3. Behrouz A. Forouzan , "Cryptography & Network Security", McGraw-Hill,2015.

ISY6407 Robotics

Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability and accuracy, Degrees of freedom of robots, Robot configurations and concept of workspace, Mechanisms and transmission, End effectors and Different types of grippers, vacuum and other methods of gripping. Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots.

Kinematics of Robots: Transformation Matrices, Inverse transformation matrices, Forward and Inverse kinematic equation for position and orientation, Denavit-Hartenberg representation of robot, inverse kinematic solution for articulated robot, Numericals. Differential Motions and velocities: Jacobian, Differential motions of a frame, Differential motion between frames, Calculation of the Jacobian, Inverse Jacobian, Numericals.

Dynamic analysis of Force: Lagrangian and Newtonian mechanics, Dynamic equations for multiple –DOF Robots, Static force analysis of Robots, Transformation of forces and moments between coordinate frames, Numericals. Trajectory Planning: Basics of Trajectory planning, Joint space trajectory planning, Cartesian Space trajectories, Numericals.

Robot Programming languages & systems: Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages. Off-line programming systems: Introduction, central issues in on-line and off-line programming. Programming examples.

Suggested Books:

1. Saha S K, "Introduction to Robotics", TMH Publication, 2008
2. Nagrath and Mittal, "Robotics and Control", Tata McGraw-Hill, 2003.
3. Fu. K.S, Gonzalez, R.C., Lee, C.S.G, "Robotics, control, sensing, Vision and Intelligence", McGraw Hill International, 1987
4. Saeed B. Niku, "Introduction to Robotics analysis, Systems & Applications", Pearson Education Singapore P. Ltd., 2002.
5. Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and sons, 2008.
6. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki and Sebastian Thurn, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Prentice Hall of India, 2005.

ISY6409 Ethical Hacking

Introduction: Understanding the importance of security, Concept of ethical hacking and essential. Terminologies-Threat, Attack, Vulnerabilities, Target of Evaluation, Exploit. Phases involved in hacking, Foot printing, Scanning, System Hacking, Session Hijacking. Buffer Overflows: Significance of Buffer Overflow Vulnerability, Why Programs/Applications are vulnerable. Reasons for Buffer Overflow Attacks. Methods of ensuring that buffer overflows are trapped,Sinffing.

SQL Injection: Attacking SQL Servers, Sniffing, Brute Forcing and finding Application, Configuration Files, Input validation attacks. Preventive Measures. Web Application Threats,

Web Application Hacking, Cross Site Scripting / XSS Flaws / Countermeasures Correct Web Application Set-up.

Web Application Security: Core Defence Mechanisms. Handling User Access, Authentication, Session Management, Access Control. Web Application Technologies: HTTP Protocol, Requests, Responses and Methods.

Attacking Authentication: Attacking Session Management, Design Flaws in Authentication, Mechanisms Attacking Forgotten Password Functionality, attacking Password change functions.

Attacking other users: Reflected XSS Vulnerabilities, Stored XSS Vulnerabilities, DOM-Based , XSS Vulnerabilities, HTTP Header Injection. Countermeasures to XSS.

Suggested Books:

1. Saha S K, "Introduction to Robotics", TMH Publication, 2008
2. Nagrath and Mittal, "Robotics and Control", Tata McGraw-Hill, 2003.
3. Fu. K.S, Gonzalez, R.C., Lee, C.S.G, "Robotics, control, sensing, Vision and Intelligence", McGraw Hill International, 1987
4. Saeed B. Niku, "Introduction to Robotics analysis, Systems & Applications", Pearson Education Singapore P. Ltd., 2002.
5. Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and sons, 2008.
6. Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki and Sebastian Thurn, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Prentice Hall of India, 2005.

ISY6411 Secure Coding

Introduction: Security, CIA Triad, Viruses, Trojans, and malware The need for secure system, proactive security development process, Threat modelling process and its benefits, Identifying the Threats by Using Attack Trees and rating threats using DREAD, cross-site scripting.

Access control, protecting secret data, Format String Problems, Integer Overflow, and Software Security Fundamentals, Buffer Overrun- Stack overrun, Heap Overrun, Array Indexing Errors.

Socket security, Avoiding Server Hijacking, Securing RPC, ActiveX and DCOM, secure .NET code, Command Injection, Failure to Handle Errors, and Security Touchpoints, Java Programming with Crypto API.

Proactive Security development process, Secure Software Development Cycle (S-SDLC), Security issues while writing SRS, Design phase security, Development Phase, Test Phase,

Database and Web-specific issues: SQL Injection Techniques and Remedies, Race conditions, Time of Check Versus Time of Use and its protection mechanisms.

Secure Coding Techniques: Protection against DoS attacks, Application Failure Attacks, CPU Starvation Attacks, Insecure Coding Practices In Java Technology. ARP Spoofing.

Suggested Books:

1. Michael Howard and David LeBlanc ,Writing Secure Code, Microsoft Press, 2nd Edition, 2004.
2. Jason Deckar,Syngress , Buffer Overflow Attacks: Detect, Exploit, Prevent,1st Edition, 2005.
3. Frank Swiderski and Window Snyder ,Threat Modeling, Microsoft Professional, 1st Edition, 2004.

ISY6413 Mobile Computing

Introduction: issues in mobile computing, overview of wireless telephony: cellular concept, GSM: air-interface, channel structure, location management: HLR, VLR, hierarchical, handoffs, channel allocation in cellular systems, Cellular telephone.

Wireless Networking, Wireless LAN Overview: MAC issues, PCF, DCF , Frame types, addressing, IEEE 802.11 standards, Blue Tooth: Architecture , Layers and protocols, Wireless multiple access protocols, TCP over wireless, Wireless applications, data broadcasting, Mobile IP.

Data management issues, data replication for mobile computers, Replication through data allocation, User profile replication scheme, optimistic replication and active replication, adaptive clustering for, mobile wireless networks, File system, Disconnected operations

Mobile Agents computing: Introduction, Advantages, Application Domains; security and fault tolerance: Protecting server, code signaling, Firewall approach; security techniques and algorithms: DES, 3DES, AES, Diffie-Hellman, RSA; transaction processing in mobile computing environment: Structure, properties, Data consistency.

Ad Hoc networks, localization, Routing protocols: Global state routing (GSR), Destination sequenced distance vector routing (DSDV), Fisheye state routing(FSR), Dynamic source routing (DSR), ABR, Route Discovery.

Suggested Books:

1. Yi-Bing Lin &Imrich Chlamtac, "Wireless and Mobile Networks Architectures", John Wiley & Sons, 2001.
2. Raj Pandya, "Mobile and Personal Communication systems and services", Prentice Hall of India, 2001.
3. Hansmann, "Principles of Mobile Computing", Wiley Dreamtech, 2004.
4. Mark Ciampa, "Guide to Designing and Implementing wireless LANs", Thomson learning, Vikas Publishing House, 2001

Elective 8

ISY6301 Bioinformatics

The Biologist & Internet: Internet basics, FTP, World Wide Web, and Introduction to Primary & Secondary database, GenBank, GCG, and ACDEB. Structure Databases: Introduction to structures, PDB, MMDB, Structure file formats, Visualizing structural information, Database structure viewers.

Information Retrieval from Biological Databases & submission of DNA Sequences to the Databases: Retrieving database entries, Integrated information retrieval: The ENTREZ system, sequence databases beyond NCBI, Medical Databases.

Sequence Alignment and Database Searching: Introduction, Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, Database similarity searching.

Multiple Sequence Alignment & Genome Mapping: Progressive alignment methods, Motifs and patterns, Probe, Presentation methods, Abscript; Different types of maps: physical, genetical, etc. Synteny, Human genome project, Application of genome mapping, Chromosome maps.

Predictive Methods Using Nucleotide & protein Sequences: Framework, marking repetitive DNA, Database search, Codon bias detection, detecting function sites in the DM, Protein identity based on composition.

Suggested Books:

1. A.D. Baxevanis and B.F.F. Ouellette , Bioinformatics: A practical guide to the analysis of genes and proteins, John Wiley and Sons. ISBN 0-471-38391-0,2004.
2. Rastogi, S.C., Mendiratta, N. and Rastogi , Bioinformatics: Concepts, Skills &Applications, CBS Publishers &Distributors, New Delhi. ISBN 13: 9788120330627, 2004.
3. Dix A., Finlay J.,Abowd G. D. and Beale R. Human Computer interaction, 3rd edition, Pearson Education, 2005

ISY6303 Data Mining

An Introduction to data ware housing, types of databases for data mining, functionalities of data mining, characteristics of data mining, classification of data mining systems, task primitives, integration of data mining with database, issues of data mining.

Data Objects and Attribute Types: Nominal Attributes, Big Data Preprocessing: reason for preprocessing, Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation.

Data cube computation and data generalization: efficient methods of data cube computation, attribute oriented induction. Associations and correlations- basic concepts, efficient and scalable frequent item sets mining methods, mining various kinds of association rules, constrain- based association mining.

Classification and prediction: issues, classification by decision tree induction, Bayesian classification, rule based classification, SVM, classification by back propagation, associative classification, lazy learners; types of prediction methods: linear regression, non-linear regression.

Cluster analysis: types of data- interval scaled, binary, categorical, ordinal, ratio scaled.

Suggested Books

1. Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann,2011
2. M.H. Dunham, "Data Mining Introductory and Advanced Topics", Pearson Education,2002.
3. Pieter Adriaans, DolfZantinge , "Data Mining", Pearson Education Asia,1997
4. Ralph Kimball, "The Data Warehouse Lifecycle toolkit", John Wiley, 2002.

ISY6305 Data Warehousing

The Building Blocks: Defining Features, Data Warehouses and Data Marts, Overview of the components, Metadata in the Data Warehouse.

Planning and Project Management: Planning Your Data Warehouse, The Data Warehouse Project, The Project Team, Project Management Considerations.

The Architectural Components: Understanding Data Warehouse Architecture, Distinguishing Characteristics, Architectural Framework, Technical Architecture, Infrastructure Supporting Architecture, Collection of Tools

Data design and data preparation: From Requirements to Data Design, The STAR Schema, STAR Schema Keys, Advantages of the STAR Schema, Data Extraction, Data Transformation, Data Loading .

OLAP in the Data Warehouse: Demand for Online Analytical Processing, Major Features and Functions, OLAP Models.

Implementation and maintenance: physical design steps, physical design considerations, physical storage, indexing the datawarehouse, performance enhancement techniques.

Suggested Books:

1. Paulraj Ponniah, "Data Warehousing Fundamentals", John Wiley,2001
2. M.H. Dunham, "Data Mining Introductory and Advanced Topics", Pearson Education,2002.
3. Han, Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann,2011.
4. Pieter Adriaans, DolfZantinge , "Data Mining", Pearson Education Asia,2002.

ISY6307 Dev-Ops

Fundaments: Beginning DevOps for Developers, Definition of DevOps, Development and operationsin conflict, Views of DevOps, DevOps and Tool suites, Traditional Project Settings, Agile Project Settings, Development and operations in agile.

Metrics and Measurement view: Quality, Capacity, resilience, Key aspects of Quality, Degeneration, Faults and Failures,Testing, Quality gates, Hawthorne effect, Importance of Team,Facilitator and Caretakers, Shared Responsibilities.

Process view: The DevOps Area Matrix, Extend Development to Operations, Value Stream mapping, Nonfunctional Requirements, Conceptual Deficits, Principal-Agent Problem, Moral Hazard, Attributes of a Unified Approach.

Technical View: Environments and infrastructure, Patterns with Appropriate Tools, Baselines, Shared version number, Overview of Topology, Parameterizing Maven's Versions Plug-In, Apply Task-Based Development, Starting with Infrastructure as Code, Test Environments with Vagrant, Jenkins, Acceptance test driven development.

Aligning Engineering and Business Operations: Creating Symmetry for Engineering and Business, Understanding Developer Culture, Business Understands Technical Capabilities, Effectively Meeting Deadlines.

Suggested Books:

1. Michael Httermann , DevOps for Developers, Apress 2012.
2. Matthew Sacks , Website Development and Operations: Streamlining DevOps for Large-Scale Websites by Matthew Sacks, Apress, 2012.
3. Gene Kim, Jez Humble, and Patrick Debois , The DevOps Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations, 2016.
4. Michael Httermann, Effective DevOps: Building a Culture of Collaboration, Affinity, and Tooling at Scale, Jennifer Davis, 2016.DevOps for Developers, Apress 2012.

ISY6309 Evolutionary computing

Optimization background and terminology: Gradient optimization methods, sampling methods, linear programming, combinatorial optimization. Evolutionary Biology background and terminology: Genotype and phenotype, unit of selection, genes and traits, chromosomes, alleles, diploid and haploid, fitness, mutation and recombination.

Genetic Algorithms: Representation, operators, and standard algorithm. The building block hypothesis and the schema theorem.

Evolutionary strategies: Evolution in continuous variables.

Artificial landscapes and test functions: The Two-armed bandit problem. Multi-modal and deceptive functions. Royal roads. N-k landscapes. Hierarchical and fractal functions. Pareto evolution. Co-evolution: Multiple populations and single-population co-evolution, relative and absolute fitness, engagement and gradient loss, the red queen effect.

Symbiosis as a source of evolutionary innovation. Macro-mutations, Major transitions in evolution, symbiosis and symbiogenesis. How symbiosis can guide evolution.Evolutionary algorithms as models: Modeling sexual selection, modeling ecosystems, artificial life.

Modularity and regularity in evolution. The scaling problem and the curse of dimensionality. Evolvability. Module acquisition. Developmental models. Compositional and hierarchical approaches.

Suggested Books:

1. Eiben, A.E., Smith, James E, Introduction to Evolutionary Computing, Springer,2015.
2. Naruya Saitou, Introduction to Evolutionary Genomics, Springer,2013.
3. Ashish M. Gujarathi, Evolutionary Computation: Techniques and Applications, CRC Press,2016

ISY6311 GPU computing

Overview of GPUs: architecture, features, programming model.System issues: cache and data management, languages and compilers, stream processing, GPU-CPU load balancing.The Age of Parallel Processing, The Rise of GPU Computing, What Is the CUDA Architecture, Applications of CUDA.Parallel Programming in CUDA C, Thread Cooperation: splitting parallel blocks, shared memory and synchronization, Constant memory and events, texture memory, Graphics interoperability, atomics, advanced atomics, streams, CUDA C on multiple GPUs.

Suggested Books:

1. K R. Fernando and M. Kilgard, "The Cg Tutorial: The Definitive Guide to Programmable Real-Time,2009.
2. E. Kandrot and J. Sanders, Cuda by Example: an Introduction to General-Purpose Gpu Programming, Addison Wesley.2011
3. David B. Kirk, Wen-mei W. Hwu, Morgan Kaufmann, Programming Massively Parallel Processors: A Hands-on Approach, 22 Feb 2010.
4. Wen-Mei w. Hwu, Morgan Kaufmann , GPU Computing GEMS Emerald Edition, February 7, 2011

ISY6313 Information Retrieval

Information Retrieval Models: Boolean Model, Vector Space Model, Relational DBMS, Probabilistic Models, Language Models.

Web Information Retrieval: citation network analysis, social collaboration (PageRank and HITS algorithms), Term Indexing: Zipf's Law, term weighting

Searching and Data Structures: Inverted files to support Boolean and Vector Models, Clustering: non-hierarchical- single pass and reallocation; hierarchical agglomerative; String Searching trees, binary trees, binary digital trees, suffix trees, etc.

Retrieval Effectiveness Evaluation: Recall, Precision, Fallout, comparing systems using average precision.

User Search Techniques: Search statements and binding, Similarity measures and ranking, Relevance feedback, Selective dissemination of information search, Weighted searches of Boolean systems, Searching the Internet and hypertext. Information Visualization: Introduction, Cognition and perception, Information visualization technologies.

Text Search Algorithms: Introduction, Software text search algorithms, Hardware text search systems. Information System Evaluation: Introduction, Measures used in system evaluation, Measurement example – TREC results.

Suggested Books:

1 Kowalski, Gerald, Mark T Maybury: Information Retrieval Systems: Theory and Implementation, Kluwer Academic Press, 1997.

2 Frakes, W.B., Ricardo Baeza-Yates: Information Retrieval Data Structures and Algorithms, Prentice Hall, 1992

3 Yates, "Modern Information Retrival", Pearson Education,2003

4 Christopher D. Manning, Prabhakar Raghavan and Hinrich Schutze," Introduction to Information Retrieval", Cambridge University Press,2008.

5 Carlos Quemada, Guillermo Bistue, Inigo Adin; Design Methodology for RF CMOS Phase Locked Loops, Artech House, February 1, 2009.

ISY6315 Intelligent system and interface

Introduction: The study of Language, Introduction to NLP, Regular Expression, Finite State Automata, Evaluating Language Understanding Systems, Different levels of Language Analysis.

Grammars and Parsing: Top-Down and Bottom-Up Parsers, Transition Network Grammars, Top-Down Chart Parsing, Feature Systems and Augmented Grammars, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.

Grammars for Natural Language: Auxiliary Verbs and Verb Phrases, Movement Phenomenon in Language, Handling questions in Context Free Grammars, Hold mechanisms in ATNs, Human preferences in Parsing, Encoding uncertainty, Deterministic Parser.

Introduction to Machine Learning: Overview of different tasks: Supervised classification, regression, control, Concept learning, information theory and decision tree, Neural networks, Deep learning

Unsupervised Learning: Clustering, Expectation Maximization, Dimensionality Reduction, Feature Selection, PCA, factor analysis, manifold learning, clustering

Case studies of Intelligent systems and interfaces, Intelligent Work Processors, Machine Translation, User Interfaces, Man-Machine Interfaces, Natural language Querying Tutoring and Authoring Systems, Speech Recognition Commercial use of NLP.

Suggested Books:

1. Duda, Richard O., Peter E. Hart, and David G. Stork. Pattern Classification. John Wiley & Sons, 2012.
2. D. Jurafsky, J. H. Martin, Speech and Language Processing, Pearson Education,(ISBN-13: 978-8131716724), 2008
3. Foundation of Statistical Natural Language Processing, Manning and Schutze, (ISBN-13: 978-0262133609), 1998.
4. Simon O. Haykin. Neural Networks and Learning Machines. Pearson Education India, 2009.

ISY6317 Introduction to cognitive science

Basic concepts of cognitive science, Domains of cognitive psychology, Cognitive Neuroscience and Nervous system.

Concept of Learning, Evaluate Classical Conditioning, Operant conditioning as well as Observational learning. Long Term Memory, Memory processes and related theories.

Illusions, Dimensions of Perception, Attention, Attention Model, Thinking, Decision making, Problem solving, intelligence, theories of intelligence.

Study of Human intelligence which will include Measurement of intelligence, Artificial Intelligence, Language, Structure of language, Comprehension of language, language acquisition and connection with brain

Cognitive process, Cognitive biases and Cognitive deficits. Emphasis on drug abuse and how drug affect cognitive abilities of a person, role of cognition in causation of various pathologies, Cognition oriented therapies.

Suggested Books:

1. Thagard, Paul. Mind: Introduction to cognitive science. Vol. 4. Cambridge, MA: MIT press, 1996.
2. Dawson, Michael RW. Mind, body, world: Foundations of cognitive science. Athabasca University Press, 2013
3. Simon O. Haykin. Neural Networks and Learning Machines. Pearson Education India, 2009.

ISY6319 Introduction to spatial computing

Introduction to Geographic Information Systems, techniques for working with geospatial Data-Collection, Analysis and Visualization of spatial data

High-performance and scalable CyberGIS, CloudGIS, exploiting spatial characteristics of data, analytical operations for geospatial scientific discoveries, Geospatial mashups.

Cloud services for spatial computing, combination of geographic data, application, software, or platform as open source solutions for spatial issues.

Spatial Data Mining techniques and problem solving, Python geospatial libraries and application to real-world problems

Volunteered Geographic Information, Big Geospatial Data and GIS design, ArcGIS Desktop, Google Map and Google Earth,SPARQL

Geo-coding of text data, Sematic web technology and GIS, Geospatial Sematic Web.

Suggested Books:

1. Duckham, Matt. Decentralized spatial computing: foundations of geosensor networks. Springer Science & Business Media, 2012.
2. Horst, Bunke, Peng Lam, and Caelli Terry Michael, eds. Spatial computing: issues in vision, multimedia and visualization technologies. Vol. 24. World Scientific, 1997.

ISY6321 Malware Analysis

Introduction to malware, OS security concepts, malware threats, evolution of malware, malware typesviruses, worms, rootkits, Trojans, bots, spyware, adware, logic bombs, malware analysis, static malware analysis, dynamic malware analysis.

X86 Architecture- Main Memory, Instructions, Opcodes and Endianness, Operands, Registers, Simple Instructions, The Stack, Conditionals, Branching, Rep Instructions, C Main Method and Offsets. Antivirus Scanning, Fingerprint for Malware, Portable Executable File Format, The PE File Headers and Sections, The Structure of a Virtual Machine, Reverse Engineering- x86 Architecture, recognizing c code constructs in assembly, c++ analysis, Analysing Windows programs, Anti-static analysis techniques-obfuscation, packing, metamorphism, polymorphism.

Live malware analysis, dead malware analysis, analyzing traces of malware- system-calls, api-calls, registries, network activities. Anti-dynamic analysis techniques-anti-vm, runtime-evasion techniques, , Malware Sandbox, Monitoring with Process Monitor, Packet Sniffing with Wire shark, Kernel vs. User-Mode Debugging, OllyDbg, Breakpoints, Tracing, Exception Handling, Patching

Downloader, Backdoors, Credential Stealers, Persistence Mechanisms, Privilege Escalation, Covert malware launching- Launchers, Process Injection, Process Replacement, Hook Injection, Detours, APC injection.

Signature-based techniques: malware signatures, packed malware signature, metamorphic and polymorphic malware signature Non-signature based techniques: similarity-based techniques, machine-learning methods, invariant inferences

Malware Characterization, Case Studies – Plankton, DroidKungFu, AnserverBot, Smartphone (Apps) Security

Suggested Books:

1. Michael Sikorski and Andrew Honig "Practical malware analysis The Hands-On Guide to Dissecting Malicious Software.2013
2. Xuxian Jiang and Yajin Zhou, Android Malware, Springer, 2013.
3. Windows Malware Analysis Essentials by Victor Marak, Packt Publishing, 2015.

ISY6323 Real time operating system

Introduction: Concept of Real Time System, Issues in real time computing, Performance measures of Real Time System, Issues in Real Time Computing, Performance measures of Real time Systems, Real Time Application. Task Assignment and Scheduling: Different task model, Scheduling hierarchy, offline vs Online Scheduling, Clock Drives.

Model of Real Time System: Processor, resources, temporal parameter, Periodic Task Model, Sporadic Task Model, Precedence Constraints and Data Dependencies, Scheduling hierarchy. Scheduling of Periodic Task: Assumptions, fixed versus dynamic priority algorithms, schedulability test for fixed priority task with arbitrary deadlines.

Scheduling of Aperiodic and Sporadic Tasks: Assumptions and approaches, deferrable, sporadic servers, slack stealing in deadline driven and fixed priority systems. Two level schemes for integrated scheduling, Scheduling for applications having flexible constrains. Resources and Resource Access Control: Assumptions on resources and their usage, resource contention, resource access control (Priority Ceiling Protocol, Priority Inheritance protocol, Slack Based Priority Ceiling Protocol, Preemption Ceiling Protocol).

Real Time Operating Systems – 1: RTOS Overview, RTOS Components, Task Management & Memory Management, Scheduling Strategies, Commercial Real-time Operating Systems.

Real time Communication: Model of real time Communication, Priority base service for switched network, Weighted Round Robin Service, Medium access Control Protocol, Real Time Protocol.

Suggested Books:

1. Michael Sikorski and Andrew Honig Practical malware analysis The Hands-On Guide to Dissecting Malicious Software, 22 February 2013
2. Xuxian Jiang and Yajin Zhou, Android Malware, Springer, 2013.
3. Victor Marak, Packt ,Windows Malware Analysis Essentials , Publishing, 2015.

ISY6325 Soft computing

Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms-Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms- Perceptrons, Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Applications of Artificial Neural Networks, Radial Basis Function networks

Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets, Membership Functions, Fuzzy rule generation and solving, Mamdani, Sugeno and Tsukamoto fuzzy rule systems, Graphical fuzzy inferencing

Operations on Fuzzy Sets: Complement, Intersection, Union, Combinations of Operations, Aggregation Operations, Nonspecificity of Fuzzy Sets, Fuzziness of Fuzzy Sets

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.

Evolutionary Computing:. Introduction, Evolutionary Techniques, Swarm Intelligence, Bacterial Foraging, Ant Colony Optimization, and Genetic Algorithm.

Introduction of Neuro-Fuzzy Systems: Architecture of Neuro Fuzzy Networks-ANFIS, MANFIS,

CANFIS and other neuro-fuzzy network architectures, Learning mechanisms.

Suggested Books:

1. Jang, Jyh-Shing Roger, Chuen-Tsai Sun, and EijiMizutani. "Neuro-fuzzy and soft computing; a computational approach to learning and machine intelligence." PHI, 1997.
2. "An Introduction to Neural Networks", Anderson J.A., PHI, 1995.
3. Neural Networks, Fuzzy Logic and Genetic Algorithms", by S. Rajasekaran& G. A. Vijayalakshmi Pai,: Synthesis & Applications, PHI, 2003.
4. "An Introduction to Genetic Algorithm", Melanie Mitchell, PHI, 1997

ISY6327 Statistical Machine Learning

Introduction: Overview of Statistical Learning, The Trade-Off Between Prediction Accuracy and Model Interpretability, Supervised versus Unsupervised Learning, Regression Versus Classification Problems.

Linear Regression: Estimating the Coefficients in simple Linear Regression, Estimating the Regression Coefficients in Multiple Linear Regression, Comparison of Linear Regression with K-Nearest Neighbors.

Classification: An Overview of Classification, Estimating the Regression Coefficients for Logistic Regression, Multiple Logistic Regression, Linear Discriminant Analysis, A Comparison of Classification Methods.

Resampling Methods: Cross-Validation, The Validation Set Approach, k-Fold Cross-Validation, Bias-Variance Trade-Off for k-Fold Cross-Validation, Cross-Validation on Classification Problems.

Unsupervised Learning: The Challenge of Unsupervised Learning, Principal Components Analysis, K-Means Clustering, Hierarchical Clustering, Practical Issues in Clustering.

Ensemble Learning: Introduction, Boosting and Regularization Paths, The "Bet on Sparsity" Principle, Regularization Paths, Over-fitting and Margins, Learning a Good Ensemble, Rule Ensembles

Suggested Books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani ,An introduction to statistical learning with applications in R, New York, Springer, 2013.
2. T. Hastie, R. Tibshirani, and J. Friedman , The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009.
3. David Barber, Machine Learning: A probabilistic approach, 2006.
4. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
5. Larry Wasserman, All of Statistics: A Concise Course in Statistical Inference, Springer Texts in Statistics, Springer-Verlag, New York, 2004.

ISY6329 Web intelligence and big data analytics

Introduction – distributed file system – Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce.

Big Data –Apache Hadoop & Hadoop EcoSystem – Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce - Data Serialization.

Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., NameNode, Secondary NameNode, and DataNode, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering –Monitoring & Maintenance.

Hadoop ecosystem components - Schedulers - Fair and Capacity, Hadoop 2.0 New Features- NameNode High Availability, HDFS Federation, MRv2, YARN, Running MRv1 in YARN.

Hive Architecture and Installation, Comparison with Traditional Database, HiveQL - Querying Data - Sorting And Aggregating, Map Reduce Scripts, Joins & Subqueries, HBase concepts- Advanced Usage, Schema Design, Advance Indexing - PIG, Zookeeper - how it helps in monitoring a cluster, HBase uses Zookeeper and how to Build Applications with Zookeeper.

Suggested Books:

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, "Professional Hadoop Solutions", Wiley, ISBN: 9788126551071, 2015.
2. Chris Eaton, Dirk derooset al. , "Understanding Big data ", McGraw Hill, 2012.
3. Tom White, "HADOOP: The definitive Guide" , O Reilly 2012.

ISY6331 Quantum computing

Introduction and Overview: qubits and pieces, Bloch sphere, quantum mechanical probabilities, quantum behaviours.

Quantum Mechanics:History of quanta, base states and superposition, structural randomness, measurement: how long is a qubit,Heisenberg's Uncertainty Principle, waveform collapsein the macroscopic limit, basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation

Fundamentals of Quantumness and Quantum Circuits: Abramsky-Coecke semantics, no-cloning theorem, quantum entanglement('spooky action at a distance'), Bell states and Bell inequalities, Pauli, Hadamard, phase, CNOT, Toffoli gates, quantum teleportation, the universality of two-qubit gates, reversible computing.

Quantum Algorithms: Deutsch-Josza algorithm,problem, quantum Fourier transform,Shor's period-finding algorithm, quantum key distribution (BB84, E91).

Quantum error-correction:The Shor code, Theory of quantum error-correction, Classical Linear codes. Calderbank–Shor–Steane codes, Stabilizer codes, Fault-tolerant quantum computation.

Quantum information theory: Distinguishing quantum states and the accessible information, Data compression, Classical information over noisy quantum channels, Quantum information overnoisy quantum channels, Entanglement as a physical resource, Quantum cryptography.

Suggested Books:

1. Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information", Cambridge (2002)
2. Riley Tipton Perry, "Quantum Computing from the Ground Up", World Scientific Publishing Ltd (2012)
3. Scott Aaronson, "Quantum Computing since Democritus", Cambridge (2013).
4. P. Kok, B. Lovett, "Introduction to Optical Quantum Information Processing", Cambridge (2010)

ISY6333 Intrusion detection and prevention

Intrusion detection, Intrusion Prevention Analysis, Rule based detection, Profile based detection, Stealth Probes Heuristics.

OSI reference model – seven layers IP,TCP, UDP, ICMP, ARP, DNS.

ARP abuses, IP abuses, TCP abuses, UDP abuses.

Memory buffer overflow, Format string overflow, Encrypted communication. TCPSplice, TCPFlow, TCPJoin Command line options, expressions, bulk capture. Tiered architecture, Sensors, agents

Packet capture, filtering, packet decoding Storage, fragment reassembly, stream reassembly Stateful inspection. Configuring Real Secure Creating and Implementing Event Filters Reporting Signatures.

Collecting requirements Defense Event viewer Network IDS Assigning packet capture to signatures. SNORT Modes, sniffer Packet capture, detection File order Filters, Alerts.

NER Sentivist Sensor Signatures Alerts and forensics. Data correlation definitions Data fusion, alert fusion Using statistical correlation Correlation coefficient Statistical inference.

Response types Response process Risk analysis Response methodology UDS and IPS incident response phases. IDS/IPS policy Standard, Baselines and procedures.

Suggested Books:

1. William Stallings, "Cryptography and Network Security: Principles and Practice.", Prentice-Hall.
2. Charles P. Pfleeger, "Security in Computing", Prentice Hall, February 5, 2015
3. Hansmann, "Principles of Mobile Computing", Wiley Dreamtech, 2004.
4. Mark Ciampa, "Guide to Designing and Implementing wireless LANs", Thomson learning, Vikas Publishing House, 2001.
5. Ray Rischpater, "Wireless Web Development", Springer Publishing, 2000
6. P.Stavronlakis, "Third Generation Mobile Telecommunication systems", Springer Publishers, 2001.

Elective 9

ISY6201 Open area research seminar

Open area research seminar

Content to be decided as per the latest development and research in the concerned filed.

SEMESTER IV

ISY652 Research Project

ISY602 Major Project II

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
Programme : M.Tech. (Microwave and Optical Communication)
Programme Specific Outcomes

1. Apply the fundamental engineering knowledge to identify, design, and analyze complex problems in the areas of microwave and optical communication.
2. Apply the modern numerical techniques, simulation tools, and appropriate hardware to design, develop and test microwave and optical components; and other complex microwave and optical networks.
3. Identify, analyze and solve real world problems in the areas of microwave and optical communication, and develop innovative, and sustainable solutions to these problems.
4. Apply the knowledge to design and develop next generation communication technology and protocol design related to optical and high frequency communication.

SCHEME OF TEACHING AND EVALUATION
MASTER OF TECHNOLOGY IN MICROWAVE AND OPTICAL COMMUNICATION (MOC)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	MOC501	Advance Electromagnetic Theory	Core	4	3	0	2	15	25	20	40	-	17
	2	MOC503	Optical Communication Systems	Core	4	3	0	2	15	25	20	40	-	
Group B	3	MOC5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	MOC5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	MOC5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	MOC502	Digital Microwave Engineering	Core	4	3	0	2	15	25	20	40	-	17
	2	MOC504	Optical Networks	Core	4	3	0	2	15	25	20	40	-	
Group D	3	MOC5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	MOC5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	MOC5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	MOC651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	MOC601	Major Project I	Core	3						40	60		
	2	MOC6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	MOC6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	MOC6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group F	1	MOC652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	MOC602	Major Project II	Core	12						40	60		

List of Elective Courses

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 1	1	MOC5401	Advanced Microwave Devices & Circuits	Elective	4	3	0	2	15	25	20	40	-	
	2	MOC5403	Photonic switching & Networks		4	3	0	2	15	25	20	40	-	
	3	MOC5405	Wireless Communications		4	3	0	2	15	25	20	40	-	
	4	MOC5407	Optics & Lasers		4	3	0	2	15	25	20	40	-	
	5	MOC5409	Quantum Computing		4	3	0	2	15	25	20	40	-	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 2	1	MOC5301	Communication Networks	Elective	3	3	0	0	20	-	30	50	-	
	2	MOC5303	RF Microwave & Millimeter circuits		3	3	0	0	20	-	30	50	-	
	3	MOC5305	Nano photonics &Plasmonics		3	3	0	0	20	-	30	50	-	
	4	MOC5307	Optical Electronics		3	3	0	0	20	-	30	50	-	
	5	MOC5309	Soft Computing in Microwave Engineering		3	3	0	0	20	-	30	50	-	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 3	1	MOC5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-	
	2	MOC5203	Optical Interconnects		2	2	0	0	20	-	30	50	-	
	3	MOC5205	Radar Engineering		2	2	0	0	20	-	30	50	-	
	4	MOC5207	Information Theory		2	2	0	0	20	-	30	50	-	
	5	MOC5209	Language Lab		2	0	0	4	-	40	-	-	60	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 4	1	MOC5402	Antenna Design	Elective	4	3	0	2	15	25	20	40	-	
	2	MOC5404	Communication Protocol Design		4	3	0	2	15	25	20	40	-	
	3	MOC5406	Optoelectronic Devices and Circuits		4	3	0	2	15	25	20	40	-	
	4	MOC5408	Optical Sensors		4	3	0	2	15	25	20	40	-	
	5	MOC5410	Satellite Communications		4	3	0	2	15	25	20	40	-	

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 5	1	MOC5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60	
	2	MOC5304	Numerical Techniques in Electroma-gnetics		3	3	0	0	20	-	30	50	-	
	3	MOC5306	EMI/EMC		3	3	0	0	20	-	30	50	-	
	4	MOC5308	Radar Signal Processing		3	3	0	0	20	-	30	50	-	
	5	MOC5310	Radiating Systems in RF Communications		3	3	0	0	20	-	30	50	-	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 6	1	MOC5202	Photo voltaics	Elective	2	2	0	0	20	-	30	50	-	
	2	MOC5204	BioPhotonics		2	2	0	0	20	-	30	50	-	
	3	MOC5206	MIMO Wireless Communication		2	2	0	0	20	-	30	50	-	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 7	1	MOC6401	Smart Antenna	Elective	4	3	0	2	15	25	20	40	-	
	2	MOC6403	Fiber optic Components		4	3	0	2	15	25	20	40	-	
	3	MOC6405	Wireless Optical Communication		4	3	0	2	15	25	20	40	-	
	4	MOC6407	Biological Effects of Electromagnetic Fields		4	3	0	2	15	25	20	40	-	
	5	MOC6409	Broadband Communication Systems		4	3	0	2	15	25	20	40	-	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
	1	MOC6301	Statistical Mathema-tics		3	3	0	0	20	-	30	50	-	
Elective 8	2	MOC6303	Integrated Optics	Elective	3	3	0	0	20	-	30	50	-	
	3	MOC6305	Quantum Electronics		3	3	0	0	20	-	30	50	-	
	4	MOC6307	Optical Computing		3	3	0	0	20	-	30	50	-	
	5	MOC6309	Optical Signal Processing		3	3	0	0	20	-	30	50	-	
	6	MOC6311	Spread Spectrum Communication		3	3	0	0	20	-	30	50	-	

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	
Elective 9	1	MOC6201	Wireless Sensor Networks	Elective	2	2	0	0	20	-	30	50	-	
	2	MOC6203	Special Topics on Optical Communications		2	2	0	0	20	-	30	50	-	
	3	MOC6205	Special Topics on Microwave communication		2	2	0	0	20	-	30	50	-	
	4	MOC6207	Neuromo-phic Engineering		2	2	0	0	20	-	30	50	-	

Semester I

Courses

MOC501 Advanced Electromagnetic Theory

Review of Maxwell equations; Concepts of Source, Duality, Uniqueness & Image theorem, Equivalence principle, Induction Theorem, Green's Function; Green's reciprocity theorem; Radiation from simple sources and apertures, Antenna Theory, Receiving antennas and various types of Antennas, Antenna pattern synthesis; Tensor, Diadic, Integral Equation, Cylindrical and Spherical Wave Function; Inhomogeneous Field Waveguides, Discontinuity and Excitation of waveguides, Periodic structure, Floquet's Theorem, Integral Transform.

Reference Books:

1. Electromagnetic wave theory for boundary-value problems: an advanced course on analytical methods by Hyo J. Eom, 1 ed, Springer 2004
2. Electromagnetic Wave Theory for Boundary-Value Problems: An Advanced Course on Analytical Methods [1 ed.] By Professor Hyo J. Eom, Springer-Verlag Berlin Heidelberg 2004

MOC503 Optical Communication Systems

Introduction to communication; review of optical sources, fibers and Detectors; Optical signaling scheme viz. IM, PL, PCM, PCM/PL, digital PPM, PRM etc. video signal; Electro-optic modulator; Various receive configurations-direct detection, Homodyne and heterodyne; Noise source in optical communication-model noise, speckle noise, shot noise, phase noise thermal noise etc. ; Direct detection receiver- analog and digital; optimum gain in APD; Signal-to-noise ratio (SNR) calculation; optimization of SNR; MDP and NEP; photon counter, receiver limits; Optical pre -amplifier design; digital hierarchy; optical line coding schemes; Performance evaluation of optical receiver for various modulation and demodulation schemes and their comparative study; Review of various optical amplifiers and SNR calculation for different applications of optical amplifier in the system; Optical fiber link design – power budget, time budget and maximum link length calculation; hybrid fiber co-axial/microwave links; fiber-in-the loop (FITL) FTTH.

Reference Books:

1. Keiser, G. (2003). Optical fiber communications. Wiley Encyclopedia of Telecommunications.
2. Senior, J. M. (2004). Optical fiber communications: principles and practice.
3. Agrawal, G. P. (2012). Fiber-optic communication systems. John Wiley & Sons.
4. Ghatak, A., & Thyagarajan, K. (1998). An introduction to fiber optics. Cambridge university press.

MOC5401 Advanced Microwave Devices & Circuits

Impedance Matching with Reactive Elements and Lumped Elements, Design of Complex Impedance Terminations, Transformers :Quarter-Wave, Binomial, Chebyshev, Tapered Transmission Lines : Exponential Taper, Taper with Triangular Distribution, Power Dividers and Couplers with odd-even mode analysis, Modelling of MEMS devices (Static and Dynamic analysis), MEMS switch circuits (Design, Reliability, Power Handling), MEMS varactors, tunable oscillators and reconfigurable subsystems, Phase Noise Analysis EBG structures: Introduction and numerical methods, Hypothesis and Floquet Bloch Transform with Decomposition of Initial Problem, Theory Analysis and Application of artificial ground plane, Metamaterials such as ENG, MNG, DNG, Homogenization of structured

materials and modeling, Transmission lines media with negative refractive index, CRLH transmission, Metamaterials Couplers and Resonators, Designing of electromagnetic compatibility, Cabling, Grounding, Balancing and Filtering, Passive and Active devices noise, Digital Circuit Radiation, Pre-compliance Measurements' Test procedures and cautions.

Reference Books:

1. Liao, S.Y. Microwave Devices & Circuits; PHI, 2003
2. Collin, R.E. Foundations for Microwave Engineering; TMH, 2000
3. Advance Microwave Circuits and systems, Edited by Vitaliy Zhuerbanko, Technical University of Denmark, Denmark
4. Advanced Microwave and Millimeter Wave Technologies, Edited By Moumita Mukherjee, University of Calcutta, India

MOC5403 Photonic Switching & Networks

Photonic Switching: Switching architectures, Single and Multistage switching, Space switching, Time switching, Combinations of space and Time switching; Interconnection networks: Crossbar, shuffle/ Omega, Benes, Close networks and their realizations, Multi wavelength switching systems, free space interconnections; Photonic networks: Introduction to computer data networks, Fiber optic LAN architecture and protocols, Ring, Star and Bus architectures, Fiber distributed data interface (FDDI): I & II, Distributed queen dual bus (DQDB); High speed bus protocol- RATO Net, Wavelength Division Multiplexed Networks

Reference Books:

1. Mukherjee, B. (2006). Optical WDM networks. Springer Science & Business Media.
2. Ramaswami, R., Sivarajan, K., & Sasaki, G. (2009). Optical networks: a practical perspective. Morgan Kaufmann.

MOC5405 Wireless Communications

Radio Propagation characteristics: models for path loss, shadowing and multipath fading (delay spread, coherence bandwidth , coherence time, Doppler Spread) Jakes channel model ; Spread spectrum Communication and multiple access techniques in mobile wireless communication: FDMA/ TDMA, CDMA; The cellular concept : frequency re-use , theory of hexagonal cell layout , Spectrum efficiency, FDMA/TDMA, CDMA, cellular system, soft capacity, Erlang capacity, GSM standards, signaling and call control, mobility management; Wireless data networking, packet array modeling on fading channels, performance analysis, links and transport layer protocols over wireless channels, mobile data network, wireless data in GSM,IS95 and GPRS.

Reference Books:

1. Wireless Communication Principle and Practices by Rappaport, Pearson
2. Wireless and personal Communication Systems by VK Garg and JE Wilkes; Prentice Hall
3. Wireless Communications by Andrea Goldsmith

MOC5407 Optics & Lasers

Geometric Optics: Refractive Index, Reflection and Refraction, Huygen's Principle, Fermat's Principle, Snell's law, Total Internal Reflection. Polarization. Wave Optics: Fresnel and Fraunhoffer Diffraction. Diffraction Grating, Interference (Double Slit and Multiple Slit), Introduction to Laser Physics: fundamentals and working principles of Gas Lasers, and p-n junction LASERS.

Reference Books:

1. Ghatak, A. Optics, Tata McGraw Hill, 4th edition.
2. Hecht, E. (1998). Optics, ed. MA: Addison-Wesley Publishing Company.

MOC5409 Quantum Computing

Basis of quantum computing, Quantum bits, Bloch sphere, Representation of a qubit, Hilber Space, Probabilities, entanglement, quantum mechanics, single and multiple Qubit gates, Design and analysis of quantum circuits, Quantum information theory, Quantum cryptography, quantum algorithms, graph states and codes, quantum error correction

Reference Books:

1. Mandel, L., & Wolf, E. (1995). Optical coherence and quantum optics. Cambridge university press.
2. Agarwal, G. S. (2012). Quantum optics. Cambridge University Press.

MOC5301 Communication Networks

OSI model, TCP/IP, UDP/IP, IPv6, and Internet applications, Markov systems, Queueing models, traffic modeling, Little's theorem, Jackson networks, flow control, routing, channel access, and cyclic redundancy checks, Wireless networks, packet radio networks, Bluetooth, GSM, IS-95, 802.11, and HiperLAN. 3G, 4G, 5G, mesh networks, ad hoc networks, sensor networks

Reference Books:

1. Communication Networks: Fundamental Concepts and key Architectures" by Alberto Leon Garcia, Indra Widjaja; TMH, 2007
2. TCP/IP Protocol Suite", 2nd Ed., by B. A. Forouzan; TMH, 2004

MOC5303 RF Microwave & Millimeter Circuits

DC and low frequency Circuit Concepts; RF Electronic Concepts; RF amplifier design and analysis; RF Oscillator design and analysis; RF/Microwave frequency conversion: Rectifier and detector design, Mixer design; Control circuit design; Analysis of planar circuits: Sample and arbitrary, Derivation Circuits characteristics; Equivalence of multi-pole planar circuits; Short boundary planar circuits, Segmentation method, Optimum planar circuits, Different types of planar transmission and their characteristics: Micro structured lines, stripe, slot, coplanar, inverted and suspended micro strip lines; Comparisons of various MIC lines; Discontinuity analysis and Equivalence circuits; Fin lines, Fin guide, H – guide, Arrow guide and surface waveguide.

Reference Books:

1. Microwave and Millimeter Wave Circuits and Systems: Engineering Design, Technologies and Applications by Apostolos Georgiadis, Hendrik Rogier, Luca Roselli, Paolo Arcioni, Wiley
2. RF Circuit Design (English, Paperback, Bowick Christopher)

3. Advanced Microwave and Millimeter Wave Technologies: Semiconductor Devices, Circuits and Systems by Moumita Mukherjee 2010

MOC5305 Nano Photonics & Plasmonics

Ray Optics, Wave Optics, Beam Optics, Review of Electromagnetic (EM) Theory, Ring Resonators, Disc Resonators; Numerical Modelling, Surface Plasmon Resonance, Localized Surface Plasmon Resonance, Photonic waveguides, Coupling conditions: Otto and Kretchmann Configuration, Grating coupling, Nanofabrication

Reference Books:

1. Maier, S. A. (2007). Plasmonics: fundamentals and applications. Springer Science & Business Media.

2. Novotny, L., & Hecht, B. (2012). Principles of nano-optics. Cambridge university press.

MOC5307 Optical Electronics

Wave propagation in Anisotropic media; Electro-Optic Effect: Phase and Amplitude modulators; Electro-Optic Effect: A.O. modulators, detectors and tunable filters; Nonlinear Optics: SHG, sum & Difference frequency generation, phase conjugation, SRS & SBS, SPM, Solitons; Non-linear effects in Optical fibers.

Reference Books:

1. Yariv, A. (1991). Optical electronics. Saunders College Publications

2. Ghatak, A. K., & Thyagarajan, K. (1989). Optical electronics. Cambridge University Press.

MOC5309 Soft Computing in Microwave Engineering

Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms- Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Adaptive Resonance Theory: Architecture, classifications, Implementation and training. Associative Memory, Introduction to Fuzzy Logic, Classical and Fuzzy Sets, Operations on Fuzzy Sets, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations, Classical Logic, Multi valued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information, Non-specificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy Sets. Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Rough Fuzzy Sets. Application of Fuzzy Logic: Medicine, Economics. Genetic Algorithm Implementation of GA Neuro-Genetic training of Backpropagation, Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications

Reference Books:

1. S. Rajasekaran and G.A.Vijaylakshmi Pai.. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India, 2004

2. K.H.Lee.. First Course on Fuzzy Theory and Applications, Springer Verlag, 2004.

3. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.

MOC5209 Language Lab

Organs of Speech, Speech Sounds, Phonetic symbols, Place of Articulation, Manner of Articulation, Stress, Syllable, Transcription of words and, short Sentences, Voiced and Voiceless Sounds Dialogues- Principles and Characteristics, Mock Interviews - Do's and Don'ts, Group Discussion - Truth Taking Strategy, Presentations and Debates - Essentials of Oral Presentations, Nature of Basic Topics, Rules.

Reference Books:

1. J.D O'Connor, Better English Pronunciation, Cambridge University
2. Peter Roach, English Phonetivs and Phonology: A Practical Course, Cambridge University
3. Meenakshi Raman and Sangeeta Sharma, Technical Communication: Principles and Practice, OUP: Delhi

MOC5203 Optical Interconnects

State-of-the-art progress in optical interconnects, Incorporation of optical communication links into computing systems, Components for optical transmitters and receivers (VCSELs, DFB Lasers, etc.), electronic techniques to boost bandwidths, approaches to electronic-photonic integration, link budgets and impediments, single-mode vs. multi-mode fibre links, and optically-enabled system architectures, challenges and opportunities of optical interconnect technologies.

Reference Books:

1. Kawai, S. (2005). Handbook of optical interconnects. CRC Press.
2. Pavesi, L., & Guillot, G. (2006). Optical interconnects. Springer series in optical sciences, 119.

MOC5205 Radar Engineering

Introduction to Radar, Radar Band Designations, Detection of Signals in Noise, SNR< Probabilities of Detection and False Alarms, Antenna Parameters and Signal Losses, Types of Radars, Pulse and CW Radars, Doppler Radar and MTI, Monopulse Tracking, Radar Signals and Clutter, Statistical Model for Surface Clutter, Detection of targets in Clutter, Devices and Radar Systems, Applications such as ESM, ECM, ECCM, IFM, and system design examples

Reference Books:

1. Introduction to Radar Systems, by Merrill I. Skolnik; Tata McGraw-Hill (3rd Edition) 2003
2. Radar Principles, by Peyton Z Peeble; John Wiley 2004

MOC5207 Information Theory

Review of Probability Theory, Information Measures such as entropy, divergence and mutual information, Szego's Theorem, lossless data compression, Slepian-Wolf Problem, Ergodic Sources, Birkhoff-Khintchine Theorem, Lempel-Ziv Optimality, Binary hypothesis testing, Channel Coding, Asymptotics, Gaussian channels, coding with feedback, Huffman coding, block codes and convolutional codes, Asymptotic equi-partition property, Scalar quantization and Panter-Dite approximation, vector quantization and rate distortion , Multi-user information theory

Reference Books:

1. Digital and Analog communication systems, K. Sam Shanmugam, John Wiley, 1996
2. Digital communication, Simon Haykin, John Wiley, 2003

Seminar

Courses

MOC502 Digital Microwave Engineering

Transmission systems environment; Statistical method in digital transmission systems; Digital modulation methods; Microwave amplifier; System gain, M-array, PSK and QAM microwave system; Correlative techniques & application to Digital Radio system design; Diversity and Protection techniques, fading techniques, digital microwave communication equipments, Digital microwave networks and its applications, Microwave propagation and its anti-fading technologies, Designing Microwave Transmission Links.

Reference Books:

1. Digital Microwave Communication by George Kizer, John Wiley and Sons
2. Microwave Transmission Networks: Planning, Design, and Deployment Second Edition by Harvey Lehpamer, McGraw Hill

MOC504 Optical Networks

Need for optical networks, multiplexing techniques, Fundamentals of supporting technology: LASERS, LEDs, Photodiodes, Fiber loss, Dispersion. Types of optical networks, Network components: Multiplexers, Filters, Amplifiers, switches and wavelength converters. Optical Networks: SONET/ SDH: Architecture, Network Topologies, Protection schemes, WDM, DWDM, Network Management and Access Networks, Photonic Packet Switching

Reference Books:

1. Mukherjee, B. (2006). Optical WDM networks. Springer Science & Business Media.
2. Lam, C. F. (Ed.). (2011). Passive optical networks: principles and practice. Elsevier.

MOC5402 Antenna Design

Fundamental parameters of Antennas; Radiation integrals and potential functions; Wire Antennas, loop antennas design and analysis of Arrays; Broadband Dipole and matching techniques; Frequency independent antennas and antenna miniaturization; Aperture antenna, Horn, Micro-strip, Reflector, Lenses, Antenna Measurements.

Reference Books:

1. Antennas: For All Applications - Kraus, John D&, Ronald J Mashefka - Tata McGraw Hill, 3rd Edition,1999
2. Antenna theory: Analysis and Design by Constantine A. Balanis, Wiley, 3rd Edition, 2005
3. Antenna Theory and Design by Stutzman, thiele
4. Antenna Theory and Design by Robert.S Elliott, Wiley IEEE Press, Revised Edition

MOC5404 Communication Protocol Design

Network Models and Architectures, Protocol Design Issues, Transmission, Multiplexing and Switching, Protocol Layering and Protocol Framework, Link Level Protocols, IETF,LAN Protocols, LAN Design and Implementation, Ethernet Switching, Wireless Networks, 802.11, IP Design, Internet Addressing, Internetworking & Routing, VLANs,IPv6 Protocol Design, IPv6 Addressing, Transport Layer Protocol Design, TCP and UDP,TCP Congestion Control, Connection Management, Network Address Translation (NAT), Application Layer Protocols Domain Name System (DNS)

Reference Books:

1. Principles of Protocol Design by Robin Sharp Springer, 2008th Edition
2. Design and validation of computer protocols by Gerard J. Holzmann
3. Communication Protocol Engineering, Pallapa Venkataram And Sunilkumar S. Manvi

MOC5406 Optoelectronic Devices and Circuits

Laser theory, Rate equations, Gain saturation, threshold; Condition, mode selection, Q-switching, Mode locking; Review of semiconductor physics: energy bands electron and holes, density of states, Fermi level, p-n junction; Homo- and hetero- junctions, Quantum wells, Semiconductor materials; LEDs and LDs: Device structure and characteristics; DFB, DBR and Quantum well lasers; Circuit design for LD transmitters and PIN receivers, OTDR and Optical spectrum analyzer

Reference Books:

1. P. Bhattacharya, Semiconductor Optoelectronic Devices, Prentice Hall of India (1997).
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007)

MOC5408 Optical Sensors

Principles of Optical Sensing, Absorption and Fluorescence spectroscopy, Distributed Scattering based optical sensing, Dielectric waveguides, Micro-cantilevers, Quantum dot sensors, Multifunctional sensor devices: Lab-on-chip, OTDR, LIDAR, and other recent optical sensor systems.

Reference Books:

1. Haus, J. (2010). Optical sensors: basics and applications. John Wiley & Sons.
2. Krohn, D. A., MacDougall, T., & Mendez, A. (2014). Fiber optic sensors: fundamentals and applications. Bellingham, WA: Spie Press.

MOC5410 Satellite Communication

Introduction to communication using satellites; Keplers laws and Orbital Mechanics; Satellite Launching; Propagation Characteristics, Frequency Spectra and bands; Satellite sub-systems; Design of satellite links and link equations; Earth station technology, Multiple access techniques; Applications of GEO, MEO, LEO and V-SATS, Mobile Satellite Communication.

Reference Books:

1. Satellite Communication, Dennis Roddy, McGraw Hill
2. Satellite Communication Systems, Richharia M. Macmillan Press

MOC5304 Numerical Techniques in Electromagnetics

Finite difference Method; Finite Segment Method; Integral equations; TLM method; Moment method; Ritz Galrkin's method; Method of lines; Spectral domain techniques; Mode matching method; Generalized scattering matrix, Transverse resonance; Practicals on development of programs using above mentioned methods.

Reference Books:

1. Numerical Techniques in Electromagnetics with MATLAB, Third Edition by Matthew N.O. Sadiku
2. Numerical and Asymptotic Techniques in Electromagnetics by R. Mittra (auth.), Professor Raj Mittra (eds.)

MOC5306 EMI/EMC

Importance of EMI/EMC, EMC rules and regulation: Different regulations, importance of considering EMC at design level of different components and systems; EMC requirement for electronic systems: Radiated emission Conducted emission Radiated susceptibility , conducted susceptibility Electrostatic discharge , Design Constraints, Advantage of EMC design , antennas for EMC; Signal spectra, Non Ideal behavior of components Cross talk there conductor lines and cross talk , Shielded wires , twisted wires , shielding, grounding , System design for EMC, Printed circuit board design including details on LISN, Spectrum Analyzer, Anechoic Chamber etc.

Reference Books:

1. Prasad Kodali.V – Engineering Electromagnetic Compatibility – S.Chand&Co. 2000
2. Clayton R.Paul – Introduction to Electromagnetic compatibility – Wiley & Sons 1992

MOC5308 Radar Signal Processing

Angle-of-Arrival Estimation in the Presence of Multipath, Spectrum Estimation Background, Thomson's Multi-Taper Method, Spectrum Estimation Procedures, Multi-taper Spectrum Estimation, F-Test for the Line Components, Low-Angle Tracking Radar Study, Non stationary Behaviour and Time–Frequency Analysis, High-Resolution Multi-taper Spectrograms, Statistical Nature of Sea Clutter: Classical Approach, Hybrid AM/FM Model of Sea Clutter, Modelling Sea Clutter, Influence of Long Waves, Statistical Data Analyses, Modulation of Long Waves, Non-stationary AR Model, Parametric Analysis of Texture Process, Bayesian Direct Filtering Procedure, Operational Details, Correlation Anomally Detection Strategy

Reference Books:

1. Adaptive Radar Signal Processing by Haykin, Simon, Wiley- Interscience, 2007\
2. Signal Processing in Radar Systems by Vyacheslav Tuzlukov, CRC Press
3. Fundamentals of Radar Signal Processing, by Mark A. Richards Second Edition McGraw-Hill Education

MOC5310 Radiating Systems in RF Communications

Basics of Radiation, Antenna parameters, radiation mechanism, review of dipole and loop antennas, microstrip antennas, radiation from apertures, field equivalence principle, aperture fields of horn antenna, reflector antennas, yagi-uda and log-periodic antennas, antenna arrays, phased arrays, optimization of array patterns, antenna synthesis techniques, antenna design and measurement of antenna parameters

Reference Books:

1. Foundations of Antenna Theory and Techniques by Vincent Fusco, Prentice Hall 1st edition, 2005
2. Antenna Theory: Analysis and Design by Balanis. C.A., 2nd edition 1996

MOC5302 Minor Project

MOC5202 Photo Voltaics

Solid state device physics, p-n and p-i-n junctions, Homojunctions and heterojunctions. Basics of absorption and recombination process, Photovoltaic efficiency, Thin film fabrication processes for photovoltaics, Silicon-based solar cells, III-V and chalcogenide-based solar cells, Organic and Inorganic solar cells.

Reference Books:

1. Mertens, K. (2018). Photovoltaics: fundamentals, technology, and practice. John Wiley & Sons.
2. Green, M. A. (2006). Third generation photovoltaics.

MOC5204 Bio-Photonics

Basics of light interaction with biological material, optical sources and photodetectors in biology, optical spectroscopy and its applications in biology, Photobiology, optical imaging, and other emerging biophotonic technologies

Reference Books:

1. Keiser, G. (2016). Biophotonics. Springer, Singapore.
2. Pavesi, L., & Fauchet, P. M. (Eds.). (2008). Biophotonics. Springer Science & Business Media.

MOC5206 MIMO Wireless Communication

Introduction to wireless communication systems, wireless fading channel models, channel estimation for MIMO systems, information theory basics for MIMO systems, capacity limit of MIMO systems, diversity performance, multi-user MIMO, space-time coding, introduction to massive MIMO wireless systems, spectral efficiency with imperfect CSI, signal processing for 5G Massive MIMO Wireless systems.

Reference Books:

1. MIMO System Technology for Wireless Communications by George Tsoulos, Taylor and Francis
2. Fundamentals of MIMO wireless Communications by Rakesh Singh Kshetrimayum
3. Foundations of MIMO Communication by Robert W.Heath JR. Angel Lozano

Courses

Research Work

MOC6401 Smart Antenna

Review of Antenna Theory and various types of antennas; Basic array theory and pattern synthesis techniques, Electromagnetic vectors Sensors, with forming applications; Spatial diversity for wireless communication direction of arrival estimation in mobile communication; Blind channel identification

and source separation in free space division Multiple access techniques, Smart antennas , system architecture; Phased array technology for wireless systems, Adaptive antennas for global systems for mobile Communication and TDMA systems.

Reference Books:

1. Smart Antenna Engineering by Ahmed El-Zooghby, Artech House Publishers 2005
2. Smart Antenna Systems and Wireless LANs by Garret T. Okamoto, W. J. Nicholson

MOC6403 Fiber Optic Components

Fundamentals of Fiber Optics, Transmission characteristics of optical fibers: Attenuation and Dispersion, Modulation and Multiplexing, Fiber Optic Components: Splicers, Couplers, Isolators, Multiplexers, Demultiplexers, Switches, Wavelength Converters, Polarization Controllers. Fiber Bragg Gratings: Fabrication and Application, Long Period Gratings, Optical Fiber Amplifiers, EDFAs

Reference Books:

1. Agrawal, G. P. (2012). Fiber-optic communication systems(Vol. 222). John Wiley & Sons.
2. Chang, K. (Ed.). (1991). Handbook of Microwave and Optical Components, Fiber and Electro-Optical Components (Vol. 4). Wiley-Interscience.

MOC6405 Wireless Optical Communication

EM Wave Propagation in free space, Fundamentals of Free Space Optics, Transceivers employed for FSO, Factors affecting performance of FSO, Long Distance FSO Communication, Modulation techniques, Optical Components for FSO waveguides, filters, couplers, amplifiers, switches and antennas, Optical signal processing for FSO Systems

Reference Books:

1. Hranilovic, S. (2006). Wireless optical communication systems. Springer Science & Business Media.
2. Uysal, M., Capsoni, C., Ghassemlooy, Z., Boucouvalas, A., & Udvary, E. (Eds.). (2016). Optical wireless communications: an emerging technology. Springer.

MOC6407 Biological Effects of Electromagnetic Fields

Mechanisms of action of EMFs on Biological systems, Mathematical modeling of EMF energy absorption in biological systems, Field computations and measurements, Biological effects of EMFs, Therapeutic Effects of electromagnetic Fields

Reference Books:

1. Biological and medical aspects of electromagnetic fields by Frank S. Barnes, Ben Greenebaum, 3rd edition CRC Press 2006
2. Bioengineering and Biophysical Aspects of Electromagnetic Fields (Handbook of Biological Effects of Electromagnetic Fields by Ben Greenebaum, Frank S. Barnes, 3rd edition CRC Press 2006

MOC6409 Broadband Communication Systems

Characterization of broadband wireline and wireless channels. Intersymbol Interference effects, Equalization methods: single-carrier and multicarrier techniques, Equalization techniques such as linear, decision feedback, precoding, zero-forcing, mean square-error, Challenges such as complexity, channel estimation, error propagation. Broadband ISDN and ATM networks, IP switching and MPLS, Real time communication over internet, packet scheduling algorithms, real world broadband communication networks.

Reference Books:

1. Introduction to Broadband Communication Systems by Cajetan M. Akujuobi, Matthew N.O. Sadiku, Chapman and Hall/CRC 2007
2. Introduction to Broadband Communication Systems 1st Edition, by Cajetan M. AkujuobiMatthew N.O. Sadiku.

MOC6301 Statistical Mathematics

Neyman-Pearson Lemma, Decision Theory; The Sequential Probability Ratio Test; Sequential Decision theory; Sufficient statistics; Estimation and Convexity; Minimal Sufficiency and the Lehmann-Scheffe property; Lower Bounds on Mean-Squared Errors: Information Inequalities, Exponential Families; Stein's Phenomenon and James-Stein's Estimators, Robustness, Breakdown points and 1-D Location M- estimates Asymptotic Normality of M-Estimates; Efficiency of estimators.

Reference Books:

1. Statistical Mathematics by Aitken A. Interscience 1947
2. Numerical Methods of Statisitcs by John F. Monahan 3rd edition Cambridge University Press 2011

MOC6303 Integrated Optics

Principles of optical Integrated circuits; Theory of optical waveguides: Planer, Rectangular-core and Rib waveguide, homogeneous and inhomogeneous waveguide; Coupled mode theory: optical waveguide couplers, tapers, bends; Passive and active waveguides- polarizer, printer ,optical amplifier, modulators and switches; Opto-electronic integrated circuits-Simulation Tools and CAD packages for optical integrated circuits; Technology: Materials and Device process, patterning and Lithography, Deposition and Diffusion techniques, Lithium Niobate based integrated optics technology- Process and Characterization; Application: Integrated optic devices and circuits for High speed long distance telecommunication, Optical processing and Optical computing.

Reference Books:

1. Chuang, S. L. (2012). Physics of photonic devices (Vol. 80). John Wiley & Sons.
2. Hunsperger, R. G. (1995). Integrated optics (Vol. 4). Springer Verlag.

MOC6305 Quantum Electronics

Propagation of light through anisotropic media, non-linear optical effects, second harmonic generation (SHG), parametric amplification, quasi phase matching, self phase modulation (SPM), cross phase modulation, four wave mixing, quantization of EM field, numbered states, coherent states, squeezed states, entangled states, application areas of quantum electronics.

Reference Books:

1. Quantum Electronics , A Yariv, John Wiley, NY, 1989
2. Scully, M. O., & Zubairy, M. S. (1997). Quantum optics cambridge university press. Cambridge, CB2 2RU, UK.

MOC6307 Optical Computing

Need of Optical Computing; Basic of Fourier Optics; Devices for optoelectronic interface: Spatial Light Modulators, Liquid crystal devices, Self-electro-optical effect Devices; Optical Transistors; Real time holograms; Optical Logic Circuits; Optical Interconnections: Crossbars Switch interconnections, Multistage interconnection Networks; Optical Memory: Hierarchies, cache and virtual memory, Optical word pattern matching, holographic memory; Logic Elements and Operations: Combinational and sequential logic, Optical matrix processing.

Reference Books:

1. Karim, M. A., & Awwal, A. A. (1992). Optical computing: an introduction. John Wiley & Sons, Inc..
2. Arsenault, H. (Ed.). (2012). Optical processing and computing. Elsevier.

MOC6309 Optical Signal Processing

Geometrical Optics; Physical Optics; Fundamentals of digital signal processing; Spectrum Analysis; Spatial Filtering Systems; Acousto-Optic Devices, Acousto-Optic Power Spectrum Analysers; Heterodyne System; Heterodyne Spectrum Analysis, Decimated Arrays and Cross Spectrum Analysis; Space Integrating Correlators; Time Integrating Systems; Two Dimensional Processing.

Reference Books:

1. Yu, F. T., & Jutamulia, S. (1992). Optical signal processing, computing, and neural networks. John Wiley & Sons, Inc..
2. Arsenault, H. (Ed.). (2012). Optical processing and computing. Elsevier.

MOC6311 Spectrum Communication

Introduction to spreading techniques, generation of spreading sequences and waveforms, properties of spreading sequences, code properties, code generator polynomials and characteristic equation, interference rejection techniques, code acquisition and tracking mechanism, fading channels and diversity, CDMA, Interference limitation in CDMA, performance analysis of CDMA and WCDMA.

Reference Books:

1. Principles of Spread Spectrum Communication Systems by Torrieri D. 2005
2. Principles of Spread-Spectrum Communication Systems by J. Scott Armstrong, Springer 2005
3. CDMA: Principles of Spread-Spectrum Communication Systems by Andrew J. Viterbi, Addison Wesley1995

MOC6201 Wireless Sensor Networks

Requirements and challanges for Wireless Sensor Networks, Comparison with Adhoc Networks, Sensor node architectures, Transceiver Design Considerations, Energy usage, Modulation schemes, Antenna Considerations, MAC Protocols, Routing and Data Gathering Protocols, Data Centric Routing, Energy aware routing, Rumor Routing, Real Time Routing Protocols, Data Aggregation Protocols, Applications of Wireless Sensor Networks.

Reference Books:

1. Wireless Sensor Networks by Nirupama Bulusu, Sanjay Jha, Artech House 2005.
2. Wireless Sensor Networks: Technology, Protocols, and Applications by Kazem Sohraby, Daniel Minoli, Taieb Znati, Wiley Interscience 2007

MOC6203 Special Topics on Optical Communication

Recent advances in the area of fiber optic or wireless optical communication based on recent papers published in the area.

MOC6205 Special Topics on Microwave Communication

Recent advances in the area of microwave communication based on recent papers published in the area.

MOC6207 Neuromorphic Engineering

Signalling and working of biological neurons, neuron models, signal encoding and statistics, Synapses, biological neural circuits, Neuromorphic design principles; FETs - device physics and sub-threshold circuits, Non-volatile memristive semiconductor devices, Electronic synapse design, Interconnection schemes for large neural networks, neuromorphic VLSI.

Reference Books:

1. Kozma, R., Pino, R. E., & Pazienza, G. E. (Eds.). (2012). Advances in neuromorphic memristor science and applications (Vol. 4). Springer Science & Business Media.
2. Lande, T. S. (Ed.). (1998). Neuromorphic systems engineering: neural networks in silicon (Vol. 447). Springer Science & Business Media.

Semester IV

MOC652 Research Project

MOC602 Major Project II

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Signal Processing & Digital Design)

Programme Specific Outcomes

1. Identify the complex problems and to devlop research-oriented approach to solve the problems in the areas of signal processing and digital system design.
2. Apply modern techniques and simulation skill to develop state of the art approaches to solve the challenges in the areas of signal processing and multimedia applications.
3. Apply the skill of self-learning and to became a mentor for student community for academic, research or industry-specific careers
4. Identify the social need and Inculcation of a socially responsible behaviour along with a highly skilled communication ability.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN SIGNAL PROCESSING & DIGITAL DESIGN (SPD)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	SPD501	Advanced Digital Signal Processing	Core	4	3	0	2	15	25	20	40	-	17
	2	SPD503	Image Analysis and Processing	Core	4	3	0	2	15	25	20	40	-	
Group B	3	SPD5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	SPD5301/5303/.....	Elective 2	Elective	3	3	0	0	15	25	20	40	-	
	5	SPD5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2/0	0	0/4	20/0	0/40	30/0	50/0	0/60	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	SPD502	Pattern Analysis and Machine Intelligence	Core	4	3	0	2	15	25	20	40	-	17
	2	SPD504	Embedded System	Core	4	3	0	2	15	25	20	40	-	
Group D	3	SPD5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	SPD5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	SPD5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	SPD651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	SPD601	Major Project I	Core	3	0	0	6			40	60		
	2	SPD6401/6403/.....	Elective 7	Elective	4	3/2	0	2/4	15	25	20	40	-	
	3	SPD6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	SPD6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group F	1	SPD652	Research Project	Core	12	0	00	12	0	-	0	100	0	
	Track 2													
	1	SPD602	Major Project II	Core	12	0	00	12	0	-	0	100	0	

LIST OF ELECTIVES :

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	SPD5401	Wireless communication	Elective	4	3	0	2	15	25	20	40	-
	2	SPD5403	Advanced Digital System Design + (concepts of Fault Tolerance)		4	3	0	2	15	25	20	40	-
	3	SPD5405	Analog Signal Processing		4	3	0	2	15	25	20	40	-
	4	SPD5407	Soft Computing		4	3	0	2	15	25	20	40	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	SPD5301	Digital Watermarking	Elective	3	3	0	0	20	-	30	50	-
	2	SPD5303	Wavelets in Signal Processing		3	3	0	0	20	-	30	50	-
	3	SPD5305	Advanced Computer Architecture		3	3	0	0	20	-	30	50	-
	4	SPD5307	Network Security &Cryptography		3	3	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	SPD5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-
Elective 3	2	SPD5203	Language Lab		2	0	0	4	0	40	0	0	60
	3	SPD5205	Statistical Signal Processing		2	2	0	0	20	-	30	50	-
	4	SPD5207	Wireless sensor networks		2	2	0	0	20	-	30	50	-
	5	SPD5209	Real Time Operating Systems		2	2	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	SPD5402	Computer Vision	Elective	4	3	0	2	15	25	20	40	-
	2	SPD5404	IOT & Applications		4	3	0	2	15	25	20	40	-
	3	SPD5406	Speech Processing		4	3	0	2	15	25	20	40	-
	4	SPD5408	Fractional Delay Filters		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	SPD5302	MINOR PROJECT	Elective	3	0	0	6	-	40	-	-	60
	2	SPD5304	Biomedical Signal Modelling		3	3	0	0	20	-	30	50	-
	3	SPD5306	Object Tracking		3	3	0	0	20	-	30	50	-
	4	SPD5308	Optimization Techniques		3	3	0	0	20	-	30	50	-
	5	SPD5310	Artificial Intelligence		3	3	0	0	20	-	30	50	-
	6	SPD5312	Reconfigurable Computing		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	SPD5202	Research Methodology & Report writing	Elective	2	2	0	0	20	-	30	50	-
	2	SPD5208	VLSI Signal processing Architecture		2	2	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	SPD6401	Multispectral signal Analysis	Elective	4	3/2	0/0	2/4	15	25	20	40	-
	2	SPD6403	Testing and Diagnosis of Digital system design		4	3/2	0/0	2/4	15	25	20	40	-
	3	SPD6405	Detection and estimation theory		4	3/2	0/0	2/4	15	25	20	40	-
	4	SPD6407	Digital Design and verification		4	3/2	0/0	2/4	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	SPD6301	Data Analytics	Elective	3	3	0	0	20	-	30	50	-
	2	SPD6303	SOC Design testing and verification		3	3	0	0	20	-	30	50	-
	3	SPD6305	FPGA Based System Design		3	3	0	0	20	-	30	50	-
	4	SPD6307	Biomedical Signal & image processing		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	SPD6201	Operation Research	Elective	2	2	0	0	20	-	30	50	-
	2	SPD6203	Multirate signal processing		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

SPD501 Advanced Digital Signal Processing

Review of Discrete time signals and systems and frequency analysis of discrete time linear time invariant systems. Discrete time systems, analysis of discrete time linear invariant systems, implementation of discrete time systems, correlation of discrete time systems, Z- Transforms, linear time invariant systems as frequency selective filters. Sampling. The Discrete Fourier transforms its properties and applications. Frequency domain sampling, properties of DFT, linear filtering methods based on DFT, Frequency analysis of signals using the DFT, Radix-2 decimation in time domain and decimation in frequency domain algorithms. Design of Digital filters, Design of FIR filters, Design of IIR filters, frequency transformations. Multirate digital signal processing, Decimation, interpolation, sampling rate conversion, filterdesign and implementation for multirate conversion, sampling rate conversion by an arbitrary factor, applications of multirate signal processing. Linear prediction and optimum linear filters, Forward and backward linear prediction, solution of the normal equations, wiener filters. Power spectrum estimation, Non-parametric and parametric methods for power spectrum estimation.

Suggested Books:

1. J.G. Proakis and Nikias, "Advanced Digital Signal Processing", Pearson Publications, 2002.
2. J.G. Proakis and D.G. Manolakis, "Digital Signal Processing", Pearson Publications, 2007.
3. G. Zelniker and F.J. Taylor, "Advanced Digital Signal Processing: Theory and Applications", John Wiley & Sons Ltd Publications, 1993.
4. S.V. Vaseghi, "Advanced Digital Signal Processing and Noise Reduction", John Wiley & Sons Ltd Publications, 2006.

SPD503 Image Analysis and Processing

Introduction, Components of digital image processing system, Image sampling, Quantization and representation. Basic gray level transformation, Histogram processing, Basics of spatial filtering, Smoothing and sharpening spatial filters. Color fundamentals, Color models, Basics of full color image processing, Color transformations, Smoothing and sharpening. Basics of filtering in frequency domain, Smoothing and sharpening frequency domain filters. Image degradation/restoration Process, Noise models, Restoration in presence of noise, Inverse filtering, Minimum mean square filtering, Geometric mean filter. Image Compression Fundamentals, Spatial and temporal redundancy, Measuring image information, Image compression methods, Loss less compression, Lossy compression. Image Segmentation Fundamentals, Point, line and edge detection, Edge linking and boundary detection, Thresholding, Region based segmentation. Introduction to morphological image processing operations, dilation and erosion, opening and closing, hit-or-miss transformation, boundary extraction, region filling, extraction connected components, convex hull, thinning, thickening, skeletons, pruning. Representation, Description and Recognition, chain codes, polygonal approximation and skeletons, Boundary descriptors-simple descriptors, shape numbers, Regional descriptors- simple, topological descriptors, Pattern and Pattern Classes-Recognition based on matching techniques and neural networks.

Suggested Books:

1. R.C. Gonzalez and R.E. Woods, "Digital Image Processing", Pearson Education, 2018.
2. A.K. Jain, "Fundamentals of Digital Image Processing", Pearson Education, PHI, 2001.
3. R.C. Gonzalez, R.E. Woods and Eddins, "Digital Image Processing using MATLAB", McGraw Hill, 2013
4. J.C. Russ and J.C. Russ, "Introduction to Image processing and analysis", CRC Press, 2017.
5. G. Georg and D. Patrice, "Image Processing and Analysis: A Primer", World Scientific Publishing Europe Ltd, 2018.
6. S. Birchfield, "Image Processing and Analysis", Cengage Learning, 2016.
7. K.R. Castleman, "Digital Image processing", Pearson Education, 2014.
8. I. Pitas, "Digital Image Processing Algorithms and Analysis", John Wiley, 2002.
9. M. Sonka, V. Hlavac and R. Boyle, "Image Processing, Analysis, and Machine Vision", Brookes/ Cole, PWS Publishing Company, Thomson Learning, 2014.

SPD5401 Wireless communication

Introduction to Wireless Communications, the wireless channel (physical modeling, linear time-varying system, discrete- time baseband model, time and frequency coherence), Statistical Fading Models, Narrowband Models, Wideband Fading, Doppler and Delay Spread, Point to-point communication (detection, diversity), Capacity of Flat and Frequency Selective Fading Channels. Probability of Symbol Error, Combined Average Error and Outage. Diversity Techniques: Transmit Diversity and Receive Diversity, Maximal Ratio Combining and Beamforming. Cellular systems (multiple access, interference management), Multicarrier Modulation: Spread Spectrum, Intro to MIMO, OFDM and Massive-MIMO. Capacity of point-to-point wireless channels (single and multi-antenna), capacity of single-antenna multiuser channels, point-to-point multiantenna (MIMO) channels and spatial multiplexing, Point-to-point MIMO capacity and multiplexing architectures.

Suggested Books:

1. D. Tse and P. Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2. A.F. Molisch, "Wireless Communications", John Wiley & Sons. Copyright, 2012.
3. Rappaport, "Wireless Communications: Principles and Practice", Pearson Education Inc., 2010.
4. A. Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

SPD5403 Advanced Digital System Design

Basics of Verilog; Introduction to finite state machine: pulse and fundamental mode of operation, realization of state table from verbal description, state diagram & Transition matrix, Mealy and Moore model machine. Reduction of flow tables of completely and incompletely specified sequential machines, concept of secondary state assignment and realization of circuits of FSM, Decomposition of FSM & composite machine equivalence between. Mealy and Moore model machine. Race and Hazard problems with asynchronous sequential machine stuck-at and bridging faults. Introduction to design with the programmable modules: ROM, PAL, PLA, FPGA, ASIC, Algorithmic state machine:

ASM Chart, data and control subsystem and implementation of ASM. Introduction to ASM designing with microprogramming; Need for reliability, Faults as the sources of unreliability, Definitions of fault tolerance, fault tolerant attributes, fault classification, distribution models for permanent ,intermittent and transient faults ; Reliability Techniques: Information redundancy, hardware redundancy, and time redundancy. Basic approaches to hardware redundancy: Error masking, Dynamic redundancy, Hybrid hardware redundancy.

Suggested Books:

1. M.D. Ciletti, "Advanced Digital Design with the Verilog HDL", Pearson Education, 2011.
2. C. Unsalan and B. Tar, "Digital System Design with FPGA: Implementation Using Verilog and VHDL", McGraw Hill Professional Publications, 2017.
3. L. Ngalamou, "Advanced Digital Systems Design with Rapid Prototyping on FPGAs using VHDL", Springer Netherlands, 2019.

SPD5405 Analog Signal Processing

Translinear bipolar and MOS Circuits: General translinear principle, various translinear circuits ; MOS analog integrated circuits: Basic building blocks, differential amplifier pair, various current mirrors, active loads, level shifter etc. and complete NMOS op-amp; Low voltage analog signal processing: need of low-voltage signal processing, CMOS op-amp design, BiCMOS op-amp design; Current mode signal processing: current mode versus voltage mode signal processing, current conveyors, current feedback op-amp and their applications; Recent trends in analog signal processing: Realization of resistors in MOS technology, NMOS OTA, CMOS OTA, CMOS transconductor, OTRA, CDBA etc.

Suggested Books:

1. R.P. Areny and J.G. Webster, "Analog Signal Processing", John Wiley & Sons, 2012.
2. E.T. Cuautle, "Integrated Circuits for Analog Signal Processing", Springer Science & Business Media, 2012.
3. Y.K. Rybin, "Electronic Devices for Analog Signal Processing", Springer, 2011.
4. P.B. Aronhime and F.W. Stephenson, "Analog Signal Processing", Springer Science & Business Media, 2013.

SPD5407 Soft Computing

Neural Networks: History, overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, Learning rules, Learning Paradigms- Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms-perceptions, Training rules, Delta, Back Propagation Algorithm, Counter propagation network, architecture, functioning & characteristics of counter Propagation network, Hopfield/ Recurrent network, configuration, stability constraints, associative memory, and characteristics, limitations and applications. Hopfield v/s Boltzman machine, Adaptive Resonance Theory: Architecture, classifications, Implementation and training. Associative Memory, Fuzzy Logic: Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations. Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. Fuzzy Logic: Classical Logic, Multi valued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information: Information & Uncertainty, Non-specificity of Fuzzy &

Crisp Sets, Fuzziness of Fuzzy Sets. Introduction of Neuro-Fuzzy Systems, Architecture of Neuro Fuzzy Networks, Rough Fuzzy Sets. Application of Fuzzy Logic: Medicine, Economics etc. Genetic Algorithm: An Overview, GA in problem solving, Implementation of GA Neuro-Genetic training of Backpropagation, Design and development of certain scientific and commercial application using computational neural network models, fuzzy models, fuzzy clustering applications and genetic algorithms in specified applications.

Suggested Books:

1. J.A. Anderson, "An Introduction to Neural Networks", PHI, MIT Press, 1995.
2. J. Hertz, A. Krogh, R.G. Palmer and A. Wesley, "Introduction to the Theory of Neural Computation", California, CRC Press, 1991.
3. G.J. Klir and B. Yuan, "Fuzzy Sets & Fuzzy Logic: Theory and Applications", PHI, Pearson Education, 2009.
4. M. Mitchell ,"An Introduction to Genetic Algorithm", PHI, MIT Press, 1998.

SPD5301 Digital Watermarking

Digital Watermarking: Basics, Models of Watermarking, Basic Message Coding, Error Correction Coding; Digital Watermarking: Theoretic Aspects, Mutual Information and Channel Capacity. How to Design a Good Digital Watermark, Information Theoretical Analysis of Digital Watermarking; Digital Watermarking Schemes (I), Spread Spectrum Watermarking, DCT-Domain Watermarking Digital Watermarking Schemes (II), Quantization Watermarking; Digital Watermarking: Protocol, A Buyer-Seller Watermarking Protocol, An Efficient and Anonymous Buyer-Seller Watermarking Protocol, Media-Specific Digital Watermarking, Video Watermarking, Audio Watermarking, Binary-Image Watermarking; Advanced Digital Watermarking, Watermarking with Side Information, Improved Spread Spectrum, Robustness to Temporal and Geometric Distortions, Affine-Resistant Watermarking, Wavelets and its application to watermarking, Non-Linear Optimization and its application to watermarking

Suggested Books:

1. F.Y. Shih, "Digital Watermarking and Steganography: Fundamentals and Techniques", CRC Press, Taylor & Francis Group, 2017.
2. I. Cox, M. Miller, J. Bloom, J. Fridrich and T. Kalker, "Digital Watermarking and Steganography", ELSEVIER, Morgan Kaufmann Publishers, 2007.
3. A.K. Singh, B. Kumar, G. Singh and A. Mohan, "Medical image Watermarking: Techniques and Applications", Springer, 2017.

SPD5303 Wavelets in Signal Processing

Limitations of Fourier Transform (FT), Short Time Fourier Transform (STFT), Time-frequency representation in STFT, Effects of window on frequency and time resolution, Limitations of STFT. Introduction to wavelets, Continuous wavelet transform (CWT), Essential and desirable properties of mother wavelet function, Translation and scaling parameters. Discrete wavelet transforms. One level and multi-level transformation, Filter analysis and filter banks, Approximation and detail coefficients. Limitations of DWT. Haar wavelet, Daubechies wavelet, Gaussian wavelet, Biorthogonal wavelet, Coiflets wavelet, Symlets wavelet, Morlet wavelet, Maxican Hat wavelet, Meyer wavelet and other wavelets. Applications of thresholding techniques in DWT, Different types of thresholding techniques. Complex wavelet transforms (CWT), Dual-tree wavelet transforms (DTWT) and Dual-tree complex

wavelet transform (DTCWT). Stationary wavelet transforms (SWT). Applications of wavelet transforms in field of biomedical signal and image processing. Latest trends in field of biomedical signal and image processing using wavelet transforms.

Suggested Books:

1. S. Mallat, "A Wavelet Tour of Signal Processing", Elsevier, 1999.
2. M. Weeks, "Digital Signal Processing Using MATLAB & Wavelets", Jones & Bartlett Publishers, 2011.
3. H.G. Stark, "Wavelets and Signal Processing: An Application-Based Introduction", Springer Science & Business Media, 2005.
4. A. Teolis, "Computational Signal Processing with Wavelets", Birkhäuser Publisher, 2017.

SPD5305 Advanced Computer Architecture

The state of Computing, Multiprocesors and Multicomputers, Multivector and SIMD Computers, PRAM and VLSI Models. Conditions of Parallelism, Program Partitioning and Scheduling, Program Flow Mechanism, System Interconnect Architecture. Advanced Processor Technology, Superscalar and vector Processors, Memory Hierarchy Technology, Virtual Memory Technology. Backplane Bus Systems, Cache Memory Organizations, Shared-Memory Organizations, Sequential and Weak Consistency Models. Linear Pipeline Processors, Nonlinear Pipelene Processors, Instruction Pipeline Design, Arithmetic Pipeline Design, Superscalar and Superpipeline Design. Multiprocessor System Interconnects Cache Coherence and Synchronization Mechanisms, Message- Passing Mechanisms. Vector Processing principles, Multivector Multiprocessors, Compound Vector Processing, Principles of Multithreading, Dataflow and Hybrid Architectures.

Suggested Books

1. K. Hwang and N. Jotwani, "Advanced Computer Architecture", McGraw Hill Education, 2016.
2. M.J. Flynn, "Computer Architecture: Pipelined and Parallel Processor Design", Jones and Barlett, Boston, 1995.
3. R. Chopra, "Advanced Computer Architecture", S. Chand Publishing, 2008.
4. S.G. Shiva, "Advanced Computer Architectures", CRC Press, 2018.
5. J.P. Hayes, "Computer Architecture and Organization", McGraw Hill, 1988.

SPD5307 Network Security & Cryptography

Security in Computing Environment: Need for Security, Security Attack, Security Services, Information Security, Methods of Protection. Planning and Enforcing Security Policies: Planning Security Policies, Risk Analysis, Security Policies for an Organization; Basics of Cryptography: Terminologies used in Cryptography, Substitution Techniques, Transposition Techniques. Encryption and Decryption: Characteristics of Good Encryption Technique, Properties of Trustworthy Encryption Systems, Types of Encryption Systems, Confusion and Diffusion, Cryptanalysis; Symmetric Key Encryption: Data Encryption Standard (DES) Algorithm, Double and Triple DES, Security of the DES, Advanced Encryption Standard (AES) Algorithm, DES and AES Comparison.Public Key Encryption: Characteristics of Public Key System, RSA Technique, Key Exchange, Diffie-Hellman Scheme, Cryptographic Hash Functions, Digital Signature, Certificates, Certificate Authorities; Protection of Computing Resources: Secure Programs, Non-malicious Program Errors, Viruses and

Other Malicious Code, Targeted Malicious Code, Methods of Control.Security Features in Operating System: Objects to be Protected, Protection Methods of Operating Systems, Memory Protection, File Protection, User Authentication; Network Security: Network Concepts, Threats in Networks, Network Security Controls. IP Security: Overview of IP Security (IPSec), IP Security Architecture, Modes of Operation, Security Associations (SA), Authentication Header (AH), Encapsulating Security Payload (ESP), Internet Key Exchange. Web Security: Web Security Requirements, Secure Socket Layer (SSL), Transport Layer Security (TLS), Secure Electronic Transaction (SET).

Suggested Books:

1. M. Kumar, "Cryptography and Network Security", Krishna Prakashan Media, 2012.
2. S.M. Musa, "Network Security and Cryptography", Mercury Learning and Information, 2018.
3. A. Kahate, "Cryptography and Network Security", Tata McGraw Hill Education, 2013.
4. B.A. Forouzan and D. Mukhopadhyay, "Cryptography and Network Security", McGraw Hill Education, 2011.

SPD5201 SEMINAR

SPD5203 Language Lab

Organs of Speech, Speech Sounds, Phonetic symbols, Place of Articulation, Manner of Articulation, Stress, Syllable, Transcription of words and, short Sentences, Voiced and Voiceless Sounds Dialogues- Principles and Characteristics, Mock Interviews - Do's and Don'ts, Group Discussion - Truth Taking Strategy, Presentations and Debates - Essentials of Oral Presentations, Nature of Basic Topics, Rules.

Suggested Books:

1. E.S. Kumar and P. Sreehari, "A Handbook for English Language Laboratories", Cambridge University Press, 2007.
2. D.S. Rani, "A Manual for English Language Laboratory", Pearson Education India, 2010.
3. N. Konar, "English Language Laboratories: A Comprehensive Manual", PHI Learning Pvt. Ltd, 2011.

SPD5205 Statistical Signal Processing

Probability; Introduction, Spinning pointers and flipping coins, Probability spaces, Discrete probability spaces, Continuous probability spaces, Independence, Elementary conditional probability; Random variables, vectors, and processes, Distributions of random variables, Random vectors and random processes, Distributions of random vectors, Independent random variables, Conditional distributions, Statistical detection and classification, Additive noise, Binary detection in Gaussian noise, Statistical estimation, Characteristic functions, Gaussian random vectors, Simple random processes, Directly given random processes, Discrete time Markov processes, nonelementary conditional probability; Expectation and averages, Functions of random variables, Functions of several random variables, Properties of expectation, Conditional expectation, Jointly Gaussian vectors, Expectation as estimation, Implications for linear estimation, Correlation and linear estimation, Correlation and covariance functions, the central limit theorem, Sample averages, Convergence of random variables, Weak law of large numbers, strong law of large numbers, Stationarity, Asymptotically uncorrelated processes; Second-order theory; Linear filtering of random processes, Linear systems I/O relations, Power spectral densities, Linearly filtered uncorrelated processes, Linear modulation, White noise,

Time averages, Mean square calculus, linear estimation and filtering, a menagerie of processes, Discrete time linear models, Sums of iid random variables, Independent stationary increment; Second-order moments of isi processes, Specification of continuous time isi processes, Moving-average and autoregressive processes, The discrete time Gauss–Markov process, Gaussian random processes, The Poisson counting process, Compound processes, Composite random processes, Exponential modulation, thermal noise, Ergodicity, Random fields.

Suggested Books:

1. R.M. Gray and L.D. Davisson, "An Introduction to Statistical Signal Processing", Cambridge University Press, 2004.
2. Kay, "Fundamentals of Statistical Processing, Volume 2: Detection Theory", Pearson Education India, 2009.
3. P.J. Schreier and L.L. Scharf, "Statistical Signal Processing of Complex-Valued Data: The Theory of Improper and Noncircular Signals", Cambridge University Press, 2010.
4. U. Spagnolini, "Statistical Signal Processing in Engineering", John Wiley & Sons, 2018.

SPD5207 Wireless sensor networks

Adhoc Networks: Introduction. Routing protocols: proactive and reactive methods, backbone and position based, and power efficient routing. Introduction and applications. Design issues and architecture of Sensor Networks. Issues and challenges, Self-organization, Localization of sensor deployment. Tree construction algorithms and analysis, Asymptotic capacity, - Lifetime optimization formulations related to Data Fusion Routing protocols: data centric, hierarchical, location based, energy efficient routing etc. Querying, data collection and processing.

Suggested Books:

1. J. Zheng and Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective", John Wiley & Sons, 2009.
2. I.M.M.E. Emary and S. Ramakrishnan, "Wireless Sensor Networks: From Theory to Applications", CRC Press, 2013.
3. W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley & Sons, 2010.
4. F. Zhao, L.J. Guibas and L. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Morgan Kaufmann Publishers, 2004.

SPD5209 Real Time Operating Systems

Introduction. Modeling Timing constraints, Scheduling Real-Time Tasks: Types of Schedulers, table-driven, Cyclic, EDF, RMA. Handling Resource sharing among real-time tasks. Scheduling Real-Time Tasks in Multiprocessor and Distributed systems. Commercial Real-time operating systems: General concepts, Unix and Windows as RTOS. Survey of commercial RTOS. Real-Time Communication. Real-Time Databases.

Suggested Books:

1. "Real-Time Operating Systems", University-Press Org, 2013.
2. Research Papers

SEMESTER II

SPD502 Pattern Analysis and Machine Intelligence

Supervised learning (generative/discriminative learning, parametric/nonparametric learning, neural networks, and support vector machines); unsupervised learning (clustering, dimensionality reduction, kernel methods); learning theory (bias/variance tradeoffs; VC theory; large margins); Reinforcement learning and adaptive control; - Discriminant Functions and Services-the Normal Distribution, Bayesian Classification, Estimating Probability Density Functions, Nearest Neighbor Rules, Bayesian Networks, Linear Classifiers, the Perceptron Algorithm, Least-Squares Methods, Nonlinear Classifiers, Multilayer Perceptron's, Back Propagation Algorithm, Decision Trees, Combinations of Classifiers, Boosting, Feature Selection, Data Preprocessing, ROC Curves, Class Separability Measures, Feature Subset Selection, Bayesian Information Criterion, Dimensionality Reduction,- Basis Vectors, Singular Value Decomposition, Independent Component Analysis, Kernel PCA, Gaussian mixture model. Clustering- Sequential Algorithms, Hierarchical Algorithms, Functional Optimization-Based Clustering, Graph Clustering, Learning Clustering, Clustering High Dimensional Data, Subspace Clustering, Cluster Validity Measures, Reinforcement learning, single state case, k-armed bandit, elements of reinforcement learning.

Suggested Books

1. C.M. Bishop, "Pattern Recognition and Machine Learning", Springer New York, 2016.
2. C.M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press, 1995.
3. R. O. Duda, P. Hart and D. Stork, "Pattern Classification", Wiley, 2012.

SPD504 Embedded System

Overview of Embedded Systems: Characteristics of Embedded Systems. Comparison of Embedded Systems with general purpose processors. General architecture and functioning of PIC micro controller. Architecture, memory interfacing, interrupts, instructions, programming and peripherals. ARM: Architecture, memory interfacing, interrupts, instructions and Assembly Language programming. Exception processing and pipeline architecture and applications. Variants of ARM architecture Digital Signal Processors: DSP Architecture, DSP applications, algorithms, data path, memory, addressing modes, peripherals. TI and Sharc family of DSP processors. System On Chip: Evolution, features, IP based design, TI OMAP architecture and peripherals. Digital Multimedia processor: Architecture and peripherals. RTOS: RT-Linux introduction, RTOS kernel, Real-Time Scheduling Bus structure: Time multiplexing, serial, parallel communication bus sfructure. Bus arbitration, DMA, PCI, AMBA, I2C and SPI Buses.

Suggested Books

1. W. Wolf, "Computers as components: Principles of Embedded Computing System Design", Morgan Kaufman Publication, 2008.
2. A.N. Sloss, D. Symes and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Morgan Kaufman Publication, 2004.
3. J.B. Peatman, "Design with PIC Microcontrollers", Pearson Education Asia, 2003.
4. T. Wilmshurst, "The Design of Small-Scale embedded systems", Palgrav, 2001.
5. P. Marwedel, "Embedded System Design", Kluwer Publishers, 2006.

SPD5402 Computer Vision

Camera geometry, camera calibration, vanishing points ;Computational tools for creating Image Panoramas: homographies, RANSAC for point-matching, SIFT (scale invariant feature transform) for detection of salient feature points ;Algorithms for - shape from shading, depth from needle map; optical flow, Kanade-Lucas-Tomasi algorithm, applications of optical flow in underwater imagery; shape from stereo, epipolar geometry; structure from motion; Photometric stereo - deriving shape from multiple images of an object taken under different lighting conditions; applications to illumination invariant face recognition, face relighting ;Machine Learning in computer vision: Face detection using Adaboost, Object detection using parts ;Some topics in computational photography/ more topics in machine learning based computer vision ;Some of the above topics will make use of concepts from signal processing (Fourier transform, convolution) and linear algebra (principal components analysis (PCA) and singular value decomposition (SVD))

Suggested Books:

1. D. A. Forsyth and J. Ponce, "Computer Vision: A Modern Approach", Prentice Hall, 2015.
2. L.G. Shapiro and G.C. Stockman, "Computer Vision", Prentice-Hall, 2001.
3. B.K.P. Horn, "Robot Vision", McGraw-Hill., 1986
4. R. Hartley and A. Zisserman, "Multiple View Geometry in Computer Vision", Cambridge University Press, 2004.

SPD5404 IOT & Applications

Defining IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs. Machine to Machine, Difference between IoT and M2M. Wireless medium access issues, MAC protocol survey, Survey routing protocols, Sensor deployment & Node discovery, Data aggregation & dissemination. Home automation, Industry applications, Surveillance applications, Other IoT applications. Design challenges, Development challenges, Security challenges.

Suggested Books

1. V. Tsiatsis, S. Karnouskos, J. Holler, D. Boyle and Catherine Mulligan, "Internet of Things: Technologies and Applications for a New Age of Intelligence", Academic Press, 2018.
2. B.K. Tripathy and J. Anuradha, "Internet of Things (IoT): Technologies, Applications, Challenges and Solutions", CRC Press, 2017.
3. V. Madisetti and A. Bahga, "Internet of Things: A Hands-On Approach", 2014.
4. W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", John Wiley & Sons, 2011.
5. A. McEwen and H. Cassimally, "Designing the Internet of Things", John Wiley & Sons, 2014.
6. O. Vermesan and P. Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers, 2013.

SPD5406 Speech Processing

Speech signal: production, perception, acoustic- phonetic characterization, signal processing methods for speech recognition, pattern- comparison techniques, speech recognition system design and implementation issues, speech recognition based on connected word models, task oriented applications of automatic speech recognition.

Suggested Books:

1. L. Rabiner, L.R. Rabiner and B.H. Juang, "Fundamentals of Speech Recognition", Prentice-Hall, 1993.
2. J. Benesty, M.M. Sondhi and Yiteng Huang, "Springer Handbook of Speech Processing", Springer Science & Business Media, 2007.
3. L. Deng and D.O. Shaughnessy, "Speech Processing: A Dynamic and Optimization-Oriented Approach", CRC Press, Marcel Dekker, Inc., 2003.
4. L.R. Rabiner and R.W. Schafer, "Introduction to Digital Speech Processing", Now Publishers Inc., 2007.

SPD5408 Fractional Delay Filters

Simple Interpolators suitable for Real Time Fractional Delay Filtering, Linearly Interpolated Delay Line (1st-Order FIR), Allpass Interpolated Delay Line (1st-Order), Linear Interpolation, Frequency Responses of Linear Interpolation for Delays between 0 and 1, Linear Interpolation as a Convolution, Up sample, Shift,Down sample View, First-Order Allpass Interpolation, Phase Delays of First-Order Allpass Interpolators for Various Desired Delays; Interpolation Overview, Well Known Closed-Form Solutions, Ideal Bandlimited (Sinc) Interpolation, The Sinc Function (Cardinal Sine'), Applications of Bandlimited Interpolation, Ideal D/A Conversion, Ideal D/A Example, Optimal Least Squares Bandlimited Interpolation Formulated as a Fractional Delay Filter, Truncated-Sinc Interpolation, Windowed Sinc Interpolation, Lowpass Filter Design; Interpolator Types, Lagrange Interpolation, Example Lagrange Basis Functions, Lagrange Interpolation Optimality, Proof of Maximum Flatness at DC, Lagrange Interpolator Amplitude Responses,Lagrange Interpolator Phase Delays, Orders 1-5, Amplitude Response of Fractional Delays, Phase Delay Over a Range of Fractional Delays,Amplitude Response Over a Range of Fractional Delays, Lagrange Interpolation Coefficients; Implementation: Lagrange Interpolation to Windowed Sinc , Variable FIR Interpolating Filter, Farrow Structure for Variable Delay FIR Filters, Thiran Allpass Interpolators, Frequency Responses of Thiran Allpass Interpolators for Fractional Delay, Large Delay Generation, L-Infinity , Chebyshev) Fractional Delay Filters, Chebyshev FD-FIR Design . Latest two research papers to be discussed and implemented.

Suggested Books:

1. T. Michalowski, "Applications of MATLAB in Science and Engineering", BoD – Books on Demand, 2011.
2. U.M. Baese, "Digital Signal Processing with Field Programmable Gate Arrays", Springer Science & Business Media, 2013.

SPD5302 MINOR PROJECT

SPD5304 Biomedical Signal Modelling

Introduction to biomedical signals: Bio-chemical, Bo-electrical and Bio-mechanical signals; ECG: Waveform, different intervals and segments, ECG data acquisition, ECG lead systems, ECG parameters and their estimation, different types of artifacts and their effect on ECG waveform; EEG: Waveform, different frequency sub-bands, different types of EEG, different EEG measuring methods, different types of artifacts and their effect on EEG. Different types of EEG artifacts. Patient-related (physiological) artifacts and system artifacts; Modelling of Power line interference, Baseline wander artifact, Electrode contact & motion artifact and Instrumentation noise. Modelling of Electro-Myogram (EMG), ECG or pulsation, Electro-Oculogram (EOG) or Ocular artifact and Ballistocardiogram;

Imaging Modalities: Survey of major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET and SPECT. MRI: Physics and signal processing for magnetic resonance imaging; Different types of MRI features and feature enhancement methods.

Suggested Books:

1. S. Cerutti and C. Marchesi, "Advance Methods of Biomedical Signal Processing", John Wiley & Sons, 2011.
2. J.L Semmlow, "Biosignal and Biomedical image processing: MATLAB based applications", Marcel Dekker Inc., 2004.
3. R.C. Gonzalez and R.E. Woods, "Digital Image Processing using MATLAB", Pearson Education International, 2017.

SPD5306 Object Tracking

Image-Based Object Tracking, Introduction, Methodologies, Background Subtraction, Temporal Difference between Frames Correlation-Based Tracking, Colour-Based Tracking, Algorithmic Account; Face Recognition, Face Recognition Approaches, Vector Representation of Images, Process Details, Algorithmic Account; Soft Computing in Image Processing, Fuzzy Logic in Image Processing, Algorithmic Account , Image Compression, Image Compression–Decompression Steps, Classifying Image Data ,Bit Allocation, Quantization, Entropy Coding, JPEG Compression, Algorithmic Account; Edge Detection, Sobel Operator, the Prewitt Operator, the Canny Operator, The Compass Operator (Edge Template Matching), The Zero-Crossing Detector, Line Detection , The Unsharp Filter, Algorithmic Account.

Suggested Books:

1. J. Hertz, A. Krogh and R.G. Palmer and A. Wesley, "Introduction to the Theory of Neural Computation", California, CRC Press, 1991.
2. G.J. Klir and B. Yuan, "Fuzzy Sets & Fuzzy Logic: Theory and Applications", PHI, Pearson Education, 2009.
3. M. Grinberg, "Feature-Based Probabilistic Data Association for Video-Based Multi-Object Tracking", KIT Scientific Publishing, 2018.
4. Stan Z. Li and Anil K. Jain, "Handbook of Face Recognition", Springer Science & Business Media, 2005.
5. C.I. Gonzalez, P. Melin, J.R. Castro and O. Castillo, "Edge Detection Methods Based on Generalized Type-2 Fuzzy Logic", Springer, 2017.

SPD5308 Optimization Techniques

Mathematical preliminaries, Linear algebra and matrices, Vector space, eigen analysis, Elements of probability theory, Elementary multivariable calculus; Introduction to linear programming model, Simplex method, Duality, Karmarkar's method; One-dimensional search methods, Gradient-based methods, Conjugate direction and quasi-Newton methods; Lagrange theorem, FONC, SONC, and SOSC conditions; Non-linear constrained optimization models, KKT conditions, Projection methods.

Suggested Books:

1. C.A. Floudas and P.M. Pardalos, "Encyclopedia of Optimization", Springer Science and Business Media, 2001.
2. S. Theodoridis, "Machine Learning: A Bayesian and Optimization Perspective", Academic Press, 2015.
3. X.S. Yang, "Optimization Techniques and Applications with Examples", John Wiley and Sons, 2018.
4. C.B. Gupta, "Optimization Techniques in Operation Research", I.K International Pvt Ltd, 2008.

SPD5310 Artificial Intelligence

AI Problems, Task Domains of AI, Introduction to Intelligent program and intelligent methodologies. Search knowledge, abstraction, Basic Problem solving Method: state space search, problem characteristics, Production systems characteristics, issues in design of Intelligent search algorithm, Hill climbing techniques, Best First search, A* Search,: AO* Search, Constraint Satisfaction, Means-End Analysis, Game Tree, Searching procedure Minimax, alpha-beta Pruning, Knowledge Representation issues, ,Predicate Logic: Unification, resolution, Natural deduction, Forward versus backward reasoning, conflict resolution, Semantic Nets, Frames, conceptual dependency, scripts, Prolog or Lisp implementation of inferences for above knowledge representation methods, Introduction to Non-Monotonic Reasoning, Logics for non-monotonic reasoning such as Default reasoning; Minimalist reasoning; implementation issues, Probabilistic Reasoning, Certainty Factors and Rule Based Reasoning, Bayesian Network, Dempster Shafer Theory, Fuzzy logic, Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, Neural Network, Genetic theorem and machine Learning Applications, Expert Systems Architecture, Domain Knowledge, Knowledge Acquisition, Case Studies: MYCIN, RI, Natural language Processing: Syntactic, Semantic and Pragmatic Analysis, Research issues in different domains.

Suggested Books:

1. E. Rich and K. Knight, "Artificial Intelligence", McGrawHill, 2004.
2. E. Alpaydin, "Introduction to Machine Learning", MIT Press, 2004
3. T. Mitchell, "Machine Learning", McGraw Hill, 1997
4. P. Langley, "Elements of Machine Learning", Morgan Kaufmann Publishers, Inc., 1995.

SPD5312 Reconfigurable Computing

Introduction to Reconfigurable Computing, FPGA Architectures, FPGA Design Cycle, Technology-independent optimization, Technology Mapping, Placement, Routing, Coarse-grained Reconfigurable Devices, Multi-FPGA Systems, Reconfigurable Computing Applications, Molecular Dynamics, Image processing, Video processing, Bioinformatics, Cryptography, Fault tolerant systems, FPGAs vs. Multicore architectures, Advanced Topics: Dynamic Reconfiguration, Partial Reconfiguration

Suggested Books:

1. S. Hauck and A. DeHon, "Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation", Elsevier, 2010.
2. C. Bobda, "Introduction to Reconfigurable Computing: Architectures, Algorithms, and Applications", Springer Science & Business Media, 2007.

3. J. Cardoso and M. Hübner, "Reconfigurable Computing: From FPGAs to Hardware/Software Codesign", Springer Science & Business Media, 2011.

4. M.B. Gokhale and P.S. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", Springer Science & Business Media, 2006.

5. N. Nedjah and C. Wang, "Reconfigurable and Adaptive Computing: Theory and Applications", CRC Press, 2018.

SPD5202 Research Methodology & Report writing

Research Concept, basis and nature of inquiry and research, Types of Scientific Research and Falsification critical thinking, Introduction to Research, Need, Ethics, Research Plan, Literature Review, Citation, Plagiarism, Report structure and Writing, Hypothesis, Modeling, Data collection, Tests of Hypothesis, Validation, Literature Review – Longitudinal and thematic, Nature of data – primary, secondary, Techniques of measurement & Scaling, sampling methods, Sample design, Collection of data – research questionnaire, survey methods, Research design – Exploratory, Experimental, Causal, Analytical, Empirical, Case research.

Suggested Books:

1. Krishnaswamy, "Management Research Methodology: Integration of Principles, Methods and Techniques", Pearson Education India, 2011.

2. G.T. Wang and K. Park, "Student Research and Report Writing: From Topic Selection to the Complete Paper", John Wiley & Sons, 2016.

3. C. R. Kothari, "Research Methodology: Methods and Techniques", New Age International, 2004.

SPD5208 VLSI Signal Processing Architecture

Introduction to DSP Systems: Introduction; representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph. Iteration Bound: Data flow graph representations, loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs. Pipelining and Parallel Processing: Pipelining and parallel processing of FIR digital filters, pipeline interleaving in digital filters: signal and multichannel interleaving. Retiming, Unfolding and Folding: retiming techniques; algorithm for unfolding, Folding transformation, systolic architecture design, systolic array design methodology. Fast Convolution, Filters and Transforms: Cook-toom algorithm, modified cooktoom algorithm, winogard algorithm, iterated convolution Algorithm strength reduction in filters and transforms.

Suggested Books

1. V. Madisetti, "VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis", IEEE Press, 1995.

2. M.A. Bayoumi, "VLSI Design Methodologies for Digital Signal Processing Architectures", Springer Science & Business Media, 2012.

3. H.J.R. Liu and K. Yao, "High-Performance VLSI Signal Processing Innovative Architectures and Algorithms, Algorithms and Architectures", Wiley, 1998.

4. K.K. Parhi, "VLSI Digital Signal Processing Systems: Design and Implementation", John Wiley & Sons, 2007.

SEMESTER III

SPD6401 Multispectral signal Analysis

Hyperspectral Sensors and Applications: Introduction, Multi-spectral Scanning Systems (MSS), Hyperspectral Systems, Airborne sensors, Spaceborne sensors, Ground Spectroscopy, Software for Hyperspectral Processing, Applications, Atmosphere and Hydrosphere, Vegetation, Soils and Geology, Environmental Hazards and Anthropogenic Activity; Mutual Information: A Similarity Measure for Intensity Based Image Registration, Introduction, Mutual Information Similarity Measure, Joint Histogram Estimation Methods, Two-Step Joint Histogram Estimation, One-Step Joint Histogram Estimation, Interpolation Induced Artifacts, Generalized Partial Volume Estimation of Joint Histograms, Optimization Issues in the Maximization of MI; Independent Component Analysis: Introduction, Concept of ICA, ICA Algorithms, Preprocessing using PCA, Information Minimization Solution for ICA, ICA Solution through Non-Gaussianity Maximization, Application of ICA to Hyperspectral Imagery, Feature Extraction Based Model, Linear Mixture Model Based Model, An ICA algorithm for Hyperspectral Image Processing, Applications using ICA; Markov Random Field Models: Introduction, MRF and Gibbs Distribution, Random Field and Neighborhood, Cliques, Potential and Gibbs Distributions

Suggested Books:

1. D.A. Landgrebe, "Signal Theory Methods in Multispectral Remote Sensing", John Wiley and Sons, 2005.
2. C.I. Chang, "Hyperspectral Data Processing: Algorithm Design and Analysis", John Wiley and Sons, 2013.
3. C. Ünsalan and K.L. Boyer, "Multispectral Satellite Image Understanding", Springer Science & Business Media, 2011.

SPD6403 Testing and Diagnosis of Digital system design

Faults in digital circuits: Fault modelling, fault detection, redundancy, equivalence, fault dominance ; Stuck at faults, bridging faults, stuck open faults, transient faults, permanent faults; Test generation for combinational circuits : Path sensitization, boolean difference, D algorithm, PODEM; Testing of sequential circuits : state identification experiments, checking experiments and machine identification; Checking circuits & self checking , totally self-checking : m/n code self-checkers and equality self checkers. Self-checking in PLAs; Design for testability: controllability and obsevability, random test generation, transition count testing, signature analysis, syndrome testable design, level sensitive scan design, BIST: LSSD on chip self-test, BILBO, BIDCO, Boundary scan standard; Fault detection in RAM and microprocessors.

Suggested Books:

1. Z. Navabi, "Digital System Test and Testable Design: Using HDL Models and Architectures", Springer Science & Business Media, 2010.
2. P.K. Lala, "An Introduction to Logic Circuit Testing", Morgan & Claypool Publishers, 2009.
3. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press 1997.
4. N.K. Jha and S. Gupta, "Testing of Digital Systems", Cambridge University Press, 2003.

SPD6405 Detection and estimation theory

Introduction of random process, Detection of signals – estimation of signal parameters, Detection and estimation in white Gaussian noise, Detection and estimation in non-white Gaussian noise. Linear estimation. Bayesian Detectors, Minimum Variance Unbiased Estimators, Maximum Likelihood Estimators, Cramer-Rao Lower Bounds, Bayesian Estimators, Minimum Mean Squared Error Estimators, Least Squares Estimators, Linear Prediction. Applications in communications and sensor networks.

Suggested Books:

1. H.V. Poor, "An Introduction to Signal Detection and Estimation", Springer Science and Business Media, 2013.
2. H.L.V. Trees, "Detection, Estimation, and Modulation Theory, Part I", John Wiley and Sons, 2004.

SPD6407 Digital Design and verification

MOS Transistors structure and operation of MOS transistor, MOS system under external Bias, Threshold voltage, MOSFET device design equation, MOSFET scaling, MOSFET capacitances. MOS Inverters static characteristics: Introduction, Resistive-Load Inverter, Inverters with n-type MOSFET load, CMOS Inverter. Switching characteristics, Inverter design with Delay constraints, Switching Power Dissipation of CMOS Inverters. Combinational MOS Logic Circuits: MOS logic circuit with depletion nMOS Loads, CMOS logic circuits, Complex Logic circuits, CMOS Transmission Gates. Sequential MOS Logic Circuits: Behavior of bistable elements, SR latch, Clocked latch and flip-flop, CMOS D latch and flip-flop. MOS Circuit Design Processes, MOS Layers, Stick Diagrams, Design Rule and Layout. CMOS Basic Circuits Layout Design: NAND, NOR, AND, OR, AOI circuits. Introduction to Hardware Verification and methodologies, Binary Decision Diagrams (BDDs) and algorithms over BDDs, Combinational equivalence checking, Temporal Logics, Modeling sequential systems and model checking, Symbolic model checking.

Suggested Books:

1. D.L. Perry and H. Foster, "Applied Formal Verification: For Digital Circuit Design", McGraw Hill Professional, 2005.
2. W.K. Lam, "Hardware Design Verification: Simulation and Formal Method-based Approaches", Prentice Hall PTR, 2005.

Elective 8

SPD6301 Data Analytics

Descriptive Statistics, Introduction to the course Descriptive Statistics Probability Distributions, Inferential Statistics through hypothesis tests Permutation & Randomization Test, Regression and ANIalysis of variance (ANOVA), Introduction to Machine Learning Concepts, Differentiating algorithmic and model based frameworks, Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification, Bias-Variance Dichotomy, Knowledge of probability theory, statistics, and programming is desirable, Model Validation Approaches Logistic Regression Linear Discriminant Analysis: Quadratic Discriminant Analysis Regression and Classification Trees Support Vector Machines, Ensemble Methods: Random Forest Neural Networks Deep learning, Clustering Associative Rule Mining Challenges for big data anlalytics, Prescriptive analytics

Suggested Books:

1. EMC Education Services, "Data Science and Big Data Analytics", John Wiley and Sons, 2015.
2. J.D. Kelleher, B.M. Namee and A.D. Arcy, "Fundamentals of Machine Learning for Predictive Data Analytics", MIT Press, 2015.

SPD6303 SOC Design testing and verification

System tradeoffs and evolution of ASIC Technology- System on chip concepts and methodology – SoC design issues –SoC challenges and components; SoC Design Flow – On-chip buses –Design process for hard cores –Soft and firm cores –Designing with hard cores, soft cores- Core and SoC design examples; Embedded memories –Simulation modes Specification of analog circuits – A to D converter –Phase- located, loops –High I/O; Core level validation –Test benches –SoC design validation – Co simulation –hardware/ Software co-verification, Case Study: Validation and test of systems on chip; SoC Test Issues – Testing of digital logic cores –Cores with boundary scan –Test methodology for design reuse– Testing of microprocessor cores – Built in self method–testing of embedded memories.

Suggested Books:

1. P. Rashinkar, P. Paterson and Leena Singh, "System-on-a-Chip Verification: Methodology and Techniques", Springer Science & Business Media, 2007.
2. V. Taraate, "Advanced HDL Synthesis and SOC Prototyping: RTL Design Using Verilog", Springer, 2018.
3. F. Nekoogar, "From ASICs to SOCs: A Practical Approach", Prentice Hall Professional, 2003.

SPD6305 FPGA Based System Design

VHDL Introduction, Introduction to VLSI Design, Front End and Back End Design, Computer Aided Design Technology, VHDL description, modelling strategies, VHDL data types, operators, attributes, signals, variables. VHDL Modelling, Modelling of Combinational & Sequential Circuits: Behavioural, Data Flow and Structural Realization of Adders, Multipliers, Comparators, Flip Flops, Shift Register, Counter, parity generator, Generics. Programmable Modules for Digital circuit designing with programmable modules: ROM, PAL, PLA, ASIC, FPGA. ASIC and FPGA Families, Programmable Asics, Programmable ASIC Logic Cells And Programmable ASIC I/O Cells Anti fuse – static RAM – EPROM and EEPROM technology – PREP benchmarks –Actel ACT – Xilinx LCA – Altera FLEX – Altera MAX DC & AC inputs and outputs –Clock & Power inputs – Xilinx I/O blocks. FPGA partitioning – partitioning methods – floor planning – placement – physical design flow – global routing – detailed routing – special routing – circuit extraction – DRC.

Suggested Books:

1. W. Wolf, "FPGA Based System design", Pearson Education, 2004.
2. V. Sklyarov, I. Skliarova, A. Barkalov and L. Titarenko, "Synthesis and Optimization of FPGA-Based Systems", Springer Science and Business Media, 2014.
3. J.J.R. Andina, E.d.l.T. Arnanz and M.D. Valdes, "FPGAs: Fundamentals, Advanced Features, and Applications in Industrial Electronics", CRC Press, 2017.

SPD6307 Biomedical Signal & image processing

Empirical Mode Decomposition (EMD): Decomposition of signal into Intrinsic Mode Functions (IMF), Stopping Criterion, Limitations of EMD, Ensemble Empirical Mode Decomposition (EEMD), Limitations of EEMD, Complete Ensemble Empirical Mode Decomposition (CEEMD), Limitations of CEEMD, Applications of EMD, EEMD and CEEMD in field of biomedical signal processing; Morphological Functions: Erosion and Dilation operators, Closing and Opening functions, Structuring element and effect of structuring element of biomedical signal and image denoising. Applications of morphological functions in field of biomedical signal and image processing; Adaptive Filters: Block diagram and Principle of adaptive filter, Transfer function and Optimization algorithms. Applications of adaptive filters in field of biomedical signal processing; Independent Component Analysis (ICA): Decomposition of signal into Independent Components (IC), Mixing Matrix. Applications of ICA in field of biomedical signal and image processing. Limitations of ICA; Modifications in ICA: Wavelet Enhanced Independent Component Analysis (wICA), Specially Constraint Independent Component Analysis (SCICA), Selection of prior constraints, Mixing matrix modification. Applications of wICA and SCICA in field of biomedical signal and image processing; Image segmentation, Different image segmentation methods, Application of FCM and its variants for image segmentation, Active contour models or Snakes, internal and external energies in active contours, level set model, Integration of level sets with active contour models, Two-Phase Level Set Formulation, Multi-Phase Level Set Formulation, Distance Regularized Level Set Evolution.

Suggested Books:

1. S. Cerutti and C. Marchesi, "Advance Methods of Biomedical Signal Processing", John Wiley & Sons, 2011.
2. J.L Semmlow, "Biosignal and Biomedical image processing: MATLAB based applications", Marcel Dekker Inc., 2004.
3. R.C. Gonzalez and R.E., "Woods Digital Image Processing using MATLAB", Pearson Education International, 2017.

SPD6201 Operation Research

Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Types of Operations Research Models, Structure of the Mathematical Model, Limitations of Operations Research, Engineering Applications, Linear Programming: Introduction, Requirements, Mathematical Formulation, Case Studies, Graphical Methods, Applications, Advantages, Limitations. Simplex Algorithms and methods, Duality Theorem, Dual simplex method, Sensitivity and Post Optimality Analysis. Transportation and Assignment Problem, Trans-shipment models.

Integer Programming, Dynamic Programming, Classical Optimization techniques, Queuing theory, Game theory and its applications, Network Planning using PERT, CPM, Project crashing, Shortest path problem, Maximum flow problem, Minimum spanning tree problem, minimum cost flow problem, Resource leveling

Suggested Books:

1. Operation Research by J. K. Sharma; Publisher: Macmillan
2. Operations Research by Hamdi A. Taha, Publisher: Pearson
3. Optimization Techniques by C. Mohan and Kusum Deep; Publishers: New Age Science

SPD6203 Multirate signal processing

Fundamentals of Multirate Theory, The sampling theorem - sampling at subnyquist rate - Basic Formulations and schemes, Basic Multirate operations- Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank,Identities- Polyphase representation, Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect reccnstruction (PR) QMF Bank - Design of an alias free QMF Bank; M-channel perfect reconstruction filter banks,Uniform band and non-uniform filter bank - tree structured filter bank- Errors created by filter bank system-Polyphase representation-perfect reconstruction systems; Perfect reconstruction (PR) filter banks, Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary,QMF Bank-Linear phase PR Filter banks- Necessary conditions for Linear phase property- Quantization,Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling; Cosine Modulated filter banks, Cosine Modulated pseudo QMF Bank- Alas cancellation-phase - Phase Distortion-Closed form expression-Polyphase structure- PR Systems; Optimising of design parameters, Balanced and Symmetrical Multirate Filters, Application and design case study. Two recent research papers on MultiRate Filter design.

Suggested Books:

1. B.W. Suter, "Multirate and Wavelet Signal Processing", Elsevier, 1997.
2. V.M. Gadre and A. Abhyankar, "Multiresolution & Multirate Signal Processing", McGraw-Hill Education, 2017.

Semester IV

SPD652 Research Project

SPD602 Major Project II

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (VLSI Design & Embedded System)

Programme Specific Outcomes

1. Apply the engineering knowledge to design and analyze problems in the field of VLSI and Embedded systems.
2. Use simulation tools and/or appropriate hardware to design, develop and validate VLSI and Embedded system applications.
3. Develop the appropriate design methodology to optimize various aspects for real-time processing in the field of VLSI and Embedded systems.
4. Apply the skill of self-learning and to become a mentor for student community for academic, research or industry-specific careers.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN VLSI DESIGN & EMBEDDED SYSTEM (VLS)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	VLS501	Analog IC Design	Core	4	3	0	2	15	25	20	40	-	17
	2	VLS503	Digital CMOS IC Design	Core	4	3	0	2	15	25	20	40	-	
Group B	3	VLS5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	VLS5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	VLS5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	VLS502	Embedded System Design	Core	4	3	0	2	15	25	20	40	-	17
	2	VLS504	Low power VLSI Design	Core	4	3	0	2	15	25	20	40	-	
Group D	3	VLS5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	VLS5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	VLS5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	30	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group E	1	VLS651	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	VLS601	Major Project I	Core	3	0	0	6			40	60		
	2	VLS6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	VLS6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	VLS6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													12
Group F	1	VLS652	Research Project	Core	12	0	0	12	0	-	0	100	0	
	Track 2													
	1	VLS602	Major Project II	Core	12	0	0	12	0	-	0	100	0	

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	VLS5401	Digital Design with HDL (Verilog)	Elective	4	3	0	2	15	25	20	40	-
	2	VLS5403	Digital Signal Processing		4	3	0	2	15	25	20	40	-
	3	VLS5405	Soft Computing		4	3	0	2	15	25	20	40	-
	4	VLS5407	IC technology		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	VLS5301	Device modelling	Elective	3	3	0	0	20	-	30	50	-
	2	VLS5303	Reconfigurable Computing		3	3	0	0	20	-	30	50	-
	3	VLS5305	Hardware software codesign		3	3	0	0	20	-	30	50	-
	4	VLS5307	Organic and Flexible Electronics		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	VLS5201	SEMINAR	Elective	2	2	0	3	2	-	100	-	-
	2	VLS5203	Micro and Nanoelectronics		2	2	0	0	20	-	30	50	-
	3	VLS5205	Micro and Nanofabrication		2	2	0	0	20	-	30	50	-
	4	VLS5207	Field Programmable Analog Arrays		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	VLS5402	Analog Filter Design	Elective	4	3	0	2	15	25	20	40	-
	2	VLS5404	Internet enabled embedded devices		4	3	0	2	15	25	20	40	-
	3	VLS5406	CAD for VLSI Systems		4	3	0	2	15	25	20	40	-
	4	VLS5408	CMOS RF Circuit Design		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	VLS5302	MINOR PROJECT	Elective	3	-	-	6	-	40	-	-	60
	2	VLS5304	FPGA based Digital Signal Processing		3	3	0	0	20	-	30	50	-
	3	VLS5306	Testing and Diagnosis of Digital System Design		3	3	0	0	20	-	30	50	-
	4	VLS5308	Memory Design and Testing		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	VLS5202	CMOS nano neuromorphic circuits	Elective	2	2	0	0	20	-	30	50	-
	2	VLS5204	Real Time Operating Systems		2	2	0	0	20	-	30	50	-
	3	VLS5206	Clock Tree Synthesis		2	2	0	0	20	-	30	50	-
	4	VLS5208	Layout design and skills with analog perspective		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	VLS6401	Mixed Signal Design	Elective	4	3	0	2	15	25	20	40	-
	2	VLS6403	Embedded Signal Processing		4	3	0	2	15	25	20	40	-
	3	VLS6405	Biomedical Circuits		4	3	0	2	15	25	20	40	-
	4	VLS6407	Fault Tolerant computing		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	VLS6301	Speech Processing	Elective	3	3	0	0	20	-	30	50	-
	2	VLS6303	Embedded Automotive systems		3	3	0	0	20	-	30	50	-
	3	VLS6305	Machine Learning		3	3	0	0	20	-	30	50	-
	4	VLS6307	Advanced Computer Architecture		3	3	0	0	20	-	30	50	-
	5	VLS6309	Embedded Software		3	3	0	0	20	-	30	50	-
	6	VLS6311	Phase Locked Loop Design		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	VLS6201	VLSI signal processing architecture	Elective	2	2	0	0	20	-	30	50	-
	2	VLS6203	FPGA based soft computing		2	2	0	0	20	-	30	50	-
	3	VLS6205	Selected topics in embedded systems		2	2	0	0	20	-	30	50	-
	4	VLS6207	Selected topics in VLSI		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

VLS501 Analog IC Design

MOSFET small signal model, MOS amplifiers- common source, source follower and common gate configurations, differential amplifiers: Single ended and Differential Operation, Gilbert Cell, Frequency and noise analysis of MOS amplifiers and differential amplifier, Frequency Compensation in two stage Amplifiers, Effect of loading in feedback networks, MOS operational amplifier: theory and design, performance characteristics, analysis of current mirrors: simple, cascode and wide swing cascode current mirror, Voltage reference circuits with emphasis on supply independent biasing and temperature-independent references.

Suggested Books:

1. B. Razavi, Design of Analog CMOS Integrated Circuits, Tata McGraw-Hill Publication, 2017.
2. A. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2013.
3. R. Gregorian and Gabor C. Temes, Analog MOS Integrated Circuits for Signal Processing, Wiley Publication, 2008.

VLS503 Digital CMOS IC design

Basic fabrication process of MOS, CMOS. Stick diagram, Design rules, Layout design, MOSFET structure, I-V relationship, threshold voltage, MOS capacitance, MOS scaling and geometry effects. Depletion and enhancement load MOS inverter, CMOS inverter, static and dynamic characteristic, The Wire: Interconnect parameters: capacitance, resistance and inductance. Electrical wire models, Power Dissipation, Design of static combinational CMOS and pseudo NMOS logic circuits, Differential Cascode voltage swing logic, Transmission gates, complementary pass transistor logic, Design of and dynamic combinational logic, Static and Dynamic Sequential logic circuit design, memory, VLSI design methodology and tools, VLSI design style, Design quality.

Suggested Books:

1. Jan M Rabaey, A.P. Chadrakasan and B. Nikolic, Digital integrated circuits a design perspective, Pearson Education, 2012.
2. Sung M.O. Kang and Y. Leblebici, CMOS digital integrated circuits, Tata McGraw Hill Publication, 2014.
3. Neil H.E. Weste and K. Eshraghian, Principle of CMOS VLSI Design, Pearson Education Publication, 2003.

VLS5401 Digital Design with HDL (Verilog)

Introduction to finite state machine: pulse and fundamental mode of operation, realization of state table from verbal description, state diagram & Transition matrix, Mealy and Moore model machine. Reduction of flow tables of completely and incompletely specified sequential machines, concept of secondary state assignment and realization of circuits of FSM, Decomposition of FSM & composite machine equivalence between. Mealy and Moore model machine. Race and Hazard problems with asynchronous sequential machine stuck-at and bridging faults. Introduction to design with the programmable modules: ROM, PAL, PLA, FPGA, ASIC, Algorithmic state machine: ASM Chart, data and control subsystem and implementation of ASM. Introduction to ASM designing with microprogramming.

Suggested Books:

1. S. Palnitkar, Verilog primer, Pearson Education Publication, 2003.
2. Z. Navabi, Verilog Digital System Design, Tata McGraw Hill Publication, 2005.
3. Z. Kohavi and N. K. Jha, Switching and Finite Automata Theory, Cambridge University Press, 2009.

VLS5403 Digital Signal Processing

Basic elements of a DSP system, Analog to digital conversion, Digital processing of Analog signals, Z-Transform and its properties. Computation of DFT: Review of DFT and its properties, DFT as a linear transformation. Efficient computation of DFT, Decimation in time Algorithm, Decimation in frequency algorithm, Chirp-z and Goertzel Algorithm, Implementation of FFT Algorithms. General difference equation, Implementation of Discrete Time Systems: Structure of FIR systems: Direct form, Cascade form, frequency sampling, and lattice. Structure of IIR systems: Direct form, Cascade form, parallel form, Lattice and Lattice-Ladder. Design of Digital Filters: FIR Filters: Design of FIR filters using windows, Design of FIR filters using frequency sampling method, Design of FIR differentiator. Design of IIR Filter: Impulse Invariance Method, Bilinear transformations, design examples: Butterworth low pass, Frequency transformations and Least square inverse method.

Suggested Books:

1. A.V. Oppenheim and Schafer, Digital Signal Processing, Pearson Education India, 2015.
2. Sen M. Kuo and Woon-Seng S. Gan, Digital Signal Processor, Architectures, Implementations and Applications, Pearson Education Publication, 2005.

VLS5405 Soft Computing

Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing. Neural Network: Structure and Function of a single neuron: Biological neuron, artificial neuron, definition of ANN, Taxonomy of neural net, Difference between ANN and human brain, characteristics and applications of ANN, single layer network, Perceptron training algorithm. Fuzzy Logic: Fuzzy set theory, Fuzzy set versus crisp set, Crisp relation & fuzzy relations ,Fuzzy systems: crisp logic, fuzzy logic, introduction & features of membership functions, Fuzzy rule base system : fuzzy propositions, formation, decomposition & aggregation of fuzzy rules, fuzzy reasoning, fuzzy inference systems, fuzzy decision making & Applications of fuzzy logic. Genetic algorithm : Fundamentals, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion &deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA, Applications & advances in GA.

Suggested Books:

1. J. Yen and R. Langari, Fuzzy Logic, Intelligence, Control and Information, Pearson Education, 2002.
2. S. Rajasekaran and G.A.Vijaylakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, Prentice Hall of India, 2003.

VLS5407 IC technology

Material properties, crystal structure, point defects, dislocations, electronic properties of defects, Crystal growth and wafer preparation, Epitaxy: Vapour –phase, molecular beam epitaxy, oxidation: Oxidation technologies in VLSI and ULSI; Characterisation of oxide films; High k and low k dielectrics for ULSI. , Lithography: Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation., Etching, Dielectric and polysilicon film deposition, Diffusion, Ion implantation, Metallization: Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; Multi-level metallisation schemes, Packaging of VLSI devices, Yield and reliability, Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technology. Nanoscale devices, MEMs.

Suggested Books:

1. S.M. Sze, VLSI Technology, 2nd Edition, McGraw Hill Education, 2017.
2. S.K. Ghandhi, VLSI Fabrication Principles, Wiley Publication, 2008.
3. J. D. Plummer and M. Deal, P. D. Griffin, Silicon VLSI Technology: Fundamentals, Practice and Modelling, Pearson Education Publication, 2009.

VLS5301 Device modelling

Overview of MOS transistor physics, Two-Terminal MOS structure, Flat -band voltage, Effect of Gate-substrate voltage on surface condition, Inversion, Small signal capacitance, Three-Terminal MOS structure, Body effect, regions of inversion, Pinch-off voltage, Four Terminal MOS Transistor, regions of inversion, charge sheet model, interpolation model, body referenced model, MOS transistor large-signal modeling, quasi-static operation, limitations of quasi-static model, introduction to non-quasi static model, MOS transistor small-signal modeling, considerations in MOS modeling for RF applications

MOSFET modeling for circuit simulation, Types of models, system for data acquisition and parameter extraction, properties of good models, Introduction to SPICE modeling, modeling of resistor, capacitor, inductor, diode, BJT, JFET, MOSFET, model parameters, Brief overview of BSIM and EKV model, Device and process simulator, Circuit simulation techniques, DC analysis, AC analysis, transient analysis, SPICE Modeling of Process Variation, Process corners, Monte Carlo simulation, and sensitivity/worst case analysis, Simulation of digital and analog circuits, transfer function, frequency response, Noise analysis, distortion and spectral analysis

Suggested Books:

1. Y. Tsividis, "Operation and modeling of MOS transistors",2 nd Edition, Oxford University Press, 2003.
2. P.W. Tuinenga, "SPICE: A Guide to Circuit Simulation and Analysis Using PSpice", 3rd Edition, Pearson, 1995.
3. P. Antognetti and G. Massobrio, "Semiconductor Device Modeling with SPICE", 2nd Edition, Tata McGraw-Hill, 2010.

VLS5303 Reconfigurable Computing

Reconfigurable Computing hardware: Device architecture, Reconfigurable Computing architecture, Reconfigurable Computing systems, Reconfiguration management, Programming Reconfigurable Systems Introduction to Reconfigurable Computing, FPGA Architectures, FPGA Design Cycle,

Technology-independent optimization, Technology Mapping, Placement, Routing, Coarse-grained Reconfigurable Devices, Multi-FPGA Systems, Reconfigurable Computing Applications, Molecular Dynamics, Image processing, Video processing, Bioinformatics, Cryptography, Fault tolerant systems, FPGAs vs. Multicore architectures , Advanced Topics: Dynamic Reconfiguration ,Partial Reconfiguration.

Suggested Books:

1. S. Hauck and A. DeHon, Reconfigurable Computing: The theory and practice of FPGA based computation, Morgan Kauffman, 2007
2. Research papers

VLS5305 Hardware Software Codesign

Hardware/Software Co-Design, Co-Design for System Specification and Modeling, Co-Design for Heterogeneous Implementation - Single-Processor Architectures with one ASIC and many ASICs, Multi-Processor Architectures, Comparison of Co- Design Approaches, Models of Computation, Requirements for Embedded System Specification. The Hardware/Software Partitioning Problem, Hardware-Software Cost Estimation, Generation of the Partitioning Graph, Formulation of the HW/SW Partitioning Problem, Optimization, HW/SW Partitioning based on Heuristic Scheduling, HW/SW Partitioning based on Genetic Algorithms.

The Co-Synthesis Problem, State-Transition Graph, Refinement and Controller Generation, Co-Synthesis Algorithm for Distributed System- Case Studies with any one application Prototyping and Emulation Techniques , Prototyping and Emulation Environments, Future Developments in Emulation and Prototyping ,Target Architecture- Architecture Specialization Techniques ,System Communication Infrastructure, Target Architectures and Application System Classes, Architectures for Control-Dominated Systems, Architectures for Data-Dominated Systems ,Mixed Systems and Less Specialized Systems Concurrency, Coordinating Concurrent Computations, Interfacing Components, Verification, Languages for System-Level Specification and Design System

Suggested Books

1. J. Staunstrup and W. Wolf, Hardware/Software Co-Design: Principles and Practice, Kluwer Academic Publication,1997.
2. R. Niemann, Hardware/Software Co-Design for Data Flow Dominated Embedded Systems, Kluwer Academic Publication, 1998.
3. G. De Micheli and R. Ernst, Reading in Hardware/Software Co-Design, Kaufmann Publishers, 2001.

VLS5307 Organic and Flexible Electronics

Flexible Organic Electronics, benefits over conventional silicon technology, applications, Limitations, Stability, Organic Materials: Conducting Polymers and Small molecules, Electrodes, Gate Dielectrics, Substrate Materials, Organic Semiconductors: *p*-type and *n*-type, Charge Transport and Injection, Energy Band Diagram. Organic Thin Film Transistor; Basic Structure, Operating Principle; Electrical Characteristics, Extraction of Performance parameters, Classification of Different Thin Film Structures, Dual Gate OTFT, Front and Back Gate Biasing, Impact of Structural Parameters on OTFT performance.OTFT Model, Contact Resistance: Origin of Contact Resistance, Contact Resistance Extraction, Models to extract performance parameters.Introduction; Classification of OLEDs, Electrical Characteristics; Multi-layered architecture, Blocking layers, Organic Solar Cell, OLED as display Applications.

Suggested Books:

1. Hagen Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley-VCH, 2006.
2. B. K. Kaushik, B. Kumar, S. Prajapati and P. Mittal, Organic Thin-Film Transistor Applications: Materials to Circuits. CRC Press, 2016.
3. K. Mullen and U. Scherf, Organic Light Emitting Devices: Synthesis, Properties and Applications, Wiley-VCH, 2005.
4. Hagen Klauk, Organic Electronics II: More Materials and Applications, Wiley-VCH, 2012.
5. F. Li, A. Nathan, Y. Wu and Beng S. Ong, Organic Thin Film Transistor Integration: A Hybrid Approach, Wiley-VCH, 2011.
6. W. Brutting, Physics of Organic Semiconductors, Wiley-VCH, 2005.

VLS5201 SEMINAR

VIS5203 Micro and Nanoelectronics

Silicon Compound Devices: SiGe BiCMOS Technology and Devices Si–Ge Interdiffusion, Dopant Diffusion, and Segregation in SiGe- and SiGe:C-Based Devices; **Advanced CMOS Devices:** Fully Depleted Devices: FDSOI and FinFET; Fully Depleted SOI Technology Overview; FinFETs: Designing for New Logic Technology; Reliability Issues in Planar and Nonplanar (FinFET) Device Architectures; High-Mobility Channels; **Post-CMOS Device Concepts**

Beyond-CMOS Devices; Stateful STT-MRAM-Based Logic for Beyond–Von Neumann Computing; Four-State Hybrid Spintronics–Straintronics for Ultralow Power Computing, nanoionic Switches as Post-CMOS Devices for Neuromorphic Electronics; **Elements of Carbon Electronics** Physics-Based Compact Graphene Device Modeling

Suggested Books:

1. T. Brozek, Micro- Nanoelectronics, Emerging Device Challenges and Solutions, CRC Press, 2014.
2. C. Gontrand, Micro- Nanoelectronics Devices, Modeling of Diffusion and Operation Processes, Elsevier, 2018.

VLS5205 Micro and Nanofabrication

Foundations of nano-photonics, Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in nano MOSFETs, Introduction to MEMS and NEMS, working principles, as micro sensors, micro actuation, MEMS/NEMS design, processing, etc., Scaling of physical systems – Geometric scaling & Electrical system scaling. The Single-Electron Transistor: The Single- Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs, Coulomb Blockade in a Nanocapacitor, Molecular SETs and Molecular Electronics.

Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists, Electron Lithography, Projection Printing, Direct writing, Electron resists. Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths etc. Lift off process, Bulk Micro machining. Oxidation, Sputter deposition, Evaporation, Chemical vapor deposition, and other thin film deposition techniques.

Suggested Books:

1. Z. Cui, Micro-Nanofabrication: Technologies and Applications, Springer, 2005.

2. S. Cabrini and S. Kawata, Nanofabrication Handbook, CRC Press, 2012.

VLS5207 Field Programmable Analog Arrays

Introduction, FPAA design technologies, Discrete time FPAA, continuous time FPAA, Op-Amp based FPAA, Differential op-amps with feedback capacitor based FPAA, OTA based FPAA, Structure of FPAA.

Suggested Books:

1. E. Pierzchala, G. Gulak, L. Chua and A. R. Vázquez, Field Programmable analog arrays, Springer, 1998.

2. Research Papers

SEMESTER II

VLS502 Embedded System Design

Overview of Embedded Systems: Characteristics of Embedded Systems. Comparison of Embedded Systems with general purpose processors. General architecture and functioning of PIC micro controller. : Architecture, memory interfacing, interrupts, instructions, programming and peripherals . ARM : Architecture, memory interfacing , interrupts, instructions and Assembly Language programming. Exception processing and pipeline architecture and applications. Variants of ARM architecture Digital Signal Processors: DSP Architecture, DSP applications, algorithms, data path, memory, addressing modes, peripherals. TI and Sharc family of DSP processors. System On Chip: Evolution, features, IP based design, TI OMAP architecture and peripherals. Digital Multimedia processor: Architecture and peripherals. RTOS: RT-Linux introduction, RTOS kernel, Real-Time Scheduling Bus structure: Time multiplexing, serial, parallel communication bus structure. Bus arbitration, DMA, PCI, AMBA, I2C and SPI Buses.

Suggested Books

1. Raj Kamal, Embedded System, Tata McGraw-Hill, 2004.

2. K. J. Ayala, The 8051 Microcontroller, Thomson DelMar Learning, 2006.

3. Deshmukh, Microcontrollers, Tata McGraw-Hill, 2006.

4. W. Wolf, Computer as components, Harcourt India Pvt. Ltd, 2002.

5. P. A. Laplante, Real time System and Analysis, Wiley, 2006.

VLS504 Low power VLSI Design

Study of power dissipation in digital ICs, Technology and device scaling, Power estimation techniques, Logical effort and transistor sizing, Low power flip flop and latch design, Low power techniques at circuit, logic architecture and system level, clocked gating, switching activity reduction, parallel and pipelined architecture at low voltage, Low voltage low power arithmetic circuit, Low power clocked tree design, Adiabatic logic, Asynchronous circuits

Suggested Books

1. G. K. Yeap, Practical Low Power Digital VLSI Design, Kluwer Academic Publishers, 2002.
2. J. Rabaey and Pedram, Low power design methodologies, Kluwer Academic Publishers, 1997.
3. K. Roy and S. Prasad, Low-Power CMOS VLSI Circuit Design, Wiley, 2000.

VLS5402 Analog Filter Design

Frequency response of bilinear and second order transfer functions, Design parameters, Active realizations: SAB, MAB, Effect of A(s), RC:CR Transformation, Sensitivity Analysis. Filter approximation Functions: Butterworth, Chebyshev, Pole locations, Filter specifications, Comparison of maximally flat and equal ripple response, Frequency Transformation: Low pass to High pass, Low pass to band pass, Low pass to band elimination. Ladder simulation by element replacement, GIC and optimal design, Realization of simple ladders, Gorski Popiel embedding technique, Bruton's FDNR technique, Operational Simulation of ladder. Switch capacitor filter, Log domain filters, Current Mode Active block based Filters: Circuit structure and analysis of operational trans -impedance Amplifier (OTIA) and various generations of current Conveyers, MOSFET-C Filters and techniques of non-linearity cancellation in MOS circuit.

Suggested Books:

1. G. Ferri and N. C. Guerrini, Low voltage low power CMOS current conveyors, Kluwer Academic Publishers, 2003.
2. R. Schaumann and Mac E.Van Valkenberg, Design of Analog Filters, Oxford, 2007.

VLS5404 Internet enabled device

Application driven Network Architecture, Review of various wireless and wireline communication protocols, Emergence of Wireless Sensors nodes, operating system for DENs, low power MAC, discovery, topology formation, collective communication, aggregation and in network processing, multihop routing, synchronization, Ad hoc routing, distributed control, coverage and security, emerging standards.

Suggested Books

1. C. Toh, Ad Hoc Mobile Wireless Networks: Protocols and Systems, Pearson Education India, 2015.
2. K. Sohraby, D. Minoli and T. Znati, Wireless Sensor Networks Technology, Protocols, and applications, Wiley-Blackwell, 2007.
3. C.S. Ram Murty and B.S. Manoj, Ad HOC Wireless Networks: Architectures & Protocols, 2nd Ed, Pearson Education, 2004.

VLS5406 CAD for VLSI Systems

VLSI automation algorithms, General graph theory and basic VLSI algorithms, Partitioning, problem formulation, classification of partitioning algorithms, Group migration algorithms, simulated annealing & evolution, other partitioning algorithms, Placement, floor planning & pin assignment, problem formulation, simulation base placement algorithms, other placement algorithms, constraint based floor planning, floor planning algorithms for mixed block & cell design, general & channel pin assignment

Global Routing, problem formulation, classification of global routing algorithms, Maze routing algorithm, line probe algorithm, Steiner tree based algorithms, ILP based approaches, problem formulation, routing, two layers over the cell routers constrained & unconstrained via minimization, compaction, problem formulation, one-dimensional compaction, two dimension based compaction, hierarchical compaction

Suggested Books:

1. N.A. Shervani, Algorithms for VLSI Physical Design Automation, Springer international, 1998.
2. S.M. Sait and Habib Youssef, VLSI Physical Design Automation – theory and practice, World Scientific, 1999.
3. S.H. Gerez, Algorithms for VLSI Design Automation, John Wiley & Sons, 1998.
4. Trimburger, Introduction to CAD for VLSI, Kluwer Academic publisher, 2002.

VLS5408 CMOS RF Circuit Design

MOSFET behavior at RF frequencies and their SPICE modeling, Parasitic elements at higher frequencies, RF filter design, matching and biasing networks, VLSI Implementation of RF system blocks, LNA design with VLSI technology, mixers, Oscillators, VCO, RF synthesizers, Power amplifier design.

Suggested Books:

1. T.H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press, 2004.
2. B. Razavi. RF Microelectronics, Pearson Education India, 2013.

VLS5302 Minor Project

VLS5304 FPGA based Digital Signal Processing

Overview of DSP, FPGA technology life cycle, DSP technology requirements, Fixed and floating point number representation, Different architectures of adders, multipliers, FPGA based implementation of logarithmic and exponential functions. FPGA based implementation of fourier transforms, cryptography algorithm for FPGAs, CORDIC Algorithm and its applications, Hardware and time optimization for FPGA based FIR digital filters.

Suggested Books:

1. R. Woods, J. McAllister, G. Lightbody and Y. Yi, FPGA- based Implementation of Signal Processing Systems, 2008.

VLS5306 Testing and Diagnosis of Digital System Design

Faults in digital circuits: Fault modelling, fault detection, redundancy, equivalence, fault location, fault dominance. Stuck at faults, bridging faults, stuck open faults, Transient faults, Permanent faults. Testing of Combinational circuits: Test generation for combinational logic circuits: Path sensitization, Boolean difference method etc CAD scheme for combinational digital circuits: D- algorithm, PODEM, FAN algorithm Testing of sequential circuits: State identification experiments, checking experiments and machine identification. Fault tolerance techniques for sequential circuits, Easily Testable Design and Diagnosis of Sequential Machine Self-checking and fail safe logic: Checking circuits &self-checking, Totally self-checking: m/n code self-checkers and equality self checkers. Self-checking

in PLAs. Self-stabilizing fault tolerant circuits Fail safe design. Design for testability: controllability and observability. Random test generation, transition count testing, signature analysis, syndrome testable design, RMC, Level sensitive scans design. BIST: LSSD on-chip self-test, BILBO, BIDCO. Fault detection in RAM and Microprocessor.

Suggested Books:

1. P. K. Lala, Fault Tolerant and Testable Hardware Design, Prentice Hall International editions, 1985.
2. M. Abramovici, M. A. Breuer and A. D. Friedman, Digital System Testing and Testable Design, Wiley, 1994.

VLS5308 Memory Design and Testing

SRAM technologies – MOS, SOI , SRAM Cell structures and architecture, peripheral circuit operation, SOI technology, Advanced SRAM architectures and technologies, Application specific SRAMs, DRAM – DRAM technology development, CMOS DRAM, cell theory and advanced cell structures, soft error failure in DRAM. Non-volatile Memories: Masked ROMs, High density ROM, PROM, CMOS PROMS, EPROM, Floating gate EPROM cell, One time programmable EPROM, EEPROM, EEPROM technology and architecture, Non-volatile SRAM, Flash Memories.

RAM fault modelling, Electrical testing, Pseudo Random testing, Megabit DRAM Testing, non-volatile memory modelling and testing, IDDQ fault modelling and testing, Application specific memory testing, RAM fault modelling, BIST techniques for memory. General reliability issues, RAM failure modes and mechanism, Nonvolatile memory reliability, reliability modelling and failure rate prediction, Design for Reliability, Reliability Test Structures, Reliability Screening and qualification, Radiation effects, Single Event Phenomenon (SEP). RAMs (FRAMs), GaAs FRAMs, Analog memories, magneto resistive RAMs (MRAMs), Memory Hybrids and MCMs (2D), Memory Stacks and MCMs (3D), Memory MCM testing and reliability issues.

Suggested Books:

1. A. Pavlov and M. Sachdev, CMOS SRAM Circuit Design and Parametric Test in Nano-Scaled Technologies: Process-Aware SRAM Design and Test, Springer, 2008.
2. K. Ishibashi and K. Osada, Low Power and Reliable SRAM Memory Cell and Array Design, Springer, 2011.

VLS5202 CMOS nano neuromorphic circuits

Introduction to classic neuromorphic circuits, (Leaky) Integrate and fire neural circuits, Ion channel models and circuits: Hodgkin-Huxley model/FitzHugh-Nagumo model/ thermodynamic model and circuits, Synapse circuits -excitatory, Hyper polarizing inhibitory, shunting inhibitory, Dendritic Computations, Cable Theory and Compartmental Models, Hsu model, Spike timing dependent plasticity,

Structural plasticity, Connectivity -Address event representation, Rent's rule, Glial Cells, Large scale systems.

Suggested Books:

1. S.P. Mohanty and A. Srivastava, Nano-CMOS and Post-CMOS Electronics: Devices and modelling, IET, 2016

VLS5204 Real Time Operating Systems

Introduction: Definition, Typical Real Time Applications; Digital Control, High Level Controls, Signal Processing etc., Release Times, Deadlines, and Timing Constraints, Hard Real Time Systems and Soft Real Time Systems, Reference Models for Real Time Systems: Processors and Resources, Temporal Parameters of Real Time Workload, Periodic Task Model, Precedence Constraints and Data Dependency. Real Time Scheduling: Common Approaches to Real Time Scheduling: Clock Driven Approach, Weighted Round Robin Approach, Priority Driven Approach, Dynamic Versus Static Systems, Optimality of Effective-Deadline-First (EDF) and Least-Slack-Time-First (LST) Algorithms, Offline Versus Online Scheduling, Scheduling A periodic and Sporadic jobs in Priority Driven and Clock Driven Systems.

Suggested Books:

1. K.C. Wang, Embedded and Real-Time Operating Systems, Springer, 2017
2. R. Mall, Real-Time Systems: Theory and Practice, Pearson, 2006

VLS5206 Clock Tree Synthesis

X-tree clock routing algorithm, H-tree clock routing algorithm, terminologies relating to clock network synthesis and routing, Design Status, Start of CTS Phase, Clock Tree Synthesis, CTS Goals, Define Clock Root Attributes, Stop, Float and Exclude Pins, Generated and Gated Clocks , User-defined or Explicit Stop Pins, Defining an Explicit Float Pin, Preserving Pre-Existing Clock Trees, Impact of Preexisting Clock Cells, Logical Design Rule Constraints, Non-Default Clock Routing.

Suggested Readings:

1. C.J. Alpert, D.P. Mehta and S.S. Sapatnekar, Handbook of Algorithms for Physical Design Automation 1st Edition, CRC Press, 2008.
2. A.B. Kahng, J. Lienig, I.L. Markov and J. Hu, VLSI Physical Design: From Graph Partitioning to Timing Closure, Springer, 2011.
3. T.J. Liang, Clock Tree Synthesis for Timing Convergence and Timing Yield Improvement in Nanometer Technologies, University of Wisconsin--Madison, 2005.

VLS5208 Layout design and skills with analog perspective

CMOS Physical design: MOS I/V Characteristics; MOS Device Model:-Small Signal Model, SPICE Models; Layout of basic devices- NMOS, PMOS, Resistor, Capacitor; Introduction to Physical verification (DRC), Analysis and design of single stage amplifiers: Common sources amplifier (CS) - with resistive, diode connected and Current source load; CS amplifier with degeneration, source follower, common gate amplifier and cascode amplifier. Analysis and design of differential amplifier, two stage operational amplifier.

Suggested Books

1. P. Allen and D.R. Holberg, CMOS Analog Circuit Design, Oxford University press, 2013.
2. B. Razavi, Design of Analog CMOS Integrated Circuits, Tata McGraw Hill, 2002.
3. Sedra and Smith, Microelectronics circuits, Oxford University Press, 2017.
4. R.L.Geiger, P. Allen and N.R.Strader, VLSI Design Techniques for Analog and Digital Circuits,Tata McGraw Hill, 2010.

SEMESTER III

VLS6401 Mixed Signal Design

Switched Capacitor Circuits: Introduction to Switched Capacitor circuits basic building blocks, Operation and Analysis, Non-ideal effects in switched capacitor circuits, Switched capacitor integrators first order filters, Switch sharing, biquad filters. Phased Lock Loop (PLL):Basic PLL topology, Dynamics of simple PLL, Charge pump PLLs-Lock acquisition, Phase/Frequency detector and charge pump, Basic charge pump PLL, Non-ideal effects in PLLs-PFD/ CP non-idealities, Jitter, in PLLs, Delay locked loops, applications. Data Converter Fundamentals: DC and dynamic specifications, Quantization noise, Nyquist rate D/A converters- Decoder based converters, Binary-Scaled converters, Thermometer-code converters, Hybrid converters. Nyquist Rate A/D Converters: Successive approximation converters, Flash converter, Two-step A/D converters, Interpolating A/D converters, Folding A/D converters, Pipelined, A/D converters, Time-interleaved converters.

Suggested Books:

1. J. Baker, CMOS mixed signal circuit design, Wiley student edition, 2008.
2. D.A. Johns and K. Martin, Analog integrated circuit design, Wiley student edition, 2011.
3. P. E. Allen and Douglas and R. Holberg, CMOS analog circuit design, Oxford university press, 2011.

VLS6403 Embedded Signal Processing

Ohm's and Kirchhoff's laws in the complex form and the concept of impedance. Passive and active analogue filters and the concepts of transfer function, cutoff frequency and Bode plots. Operational Amplifier. Fourier, Laplace and z transformation of continuous and discrete signals and systems. Sampling theorem. The concepts of poles, zeros and amounts surfaces. Stability and causality. Analysis and synthesis of analogue and digital filters. Auto- and cross-correlation, matched filters. Examples of applications. Implementation of digital filters in signal processors (DSP), choice of filter architecture with regard to the numerical limitations, real-time programming of DSPs in an imperative language.

Suggested Books:

1. Sen M. Kuo and Woon-Seng Gan, Embedded Signal Processing with the Micro Signal Architecture, Wiley, 2007.
2. R. Oshana, DSP for Embedded and Real-Time Systems, Newnes, 2012

VLS6405 Biomedical Circuits

Introduction, circuit variables, sources and resistances, node-voltage method, 21 mesh current method, source transformation, Thevenin equivalent, biopotentials, power with phasors, electrodes, transducers, biosensors, biopotential amplifiers, biotelemetry, cardiovascular measurements, electrosurgical units, recording of ECG, EEG, ERG.

Suggested Books:

1. R. S. Khandpur. Biomedical Instrumentation: Technology and Applications,Tata McGraw Hill Publishers, 2004.
2. R. S. Khandpur. Handbook Of Biomedical Instrumentation, Tata McGraw Hill Publishers, 2014.

VLS6407 Fault Tolerant computing

Concept of reliability; Parallel computing modules and arcnitectures; Applications of coding theory for fault-tolerant systems; Redundancies: static, dynamic and hybrid; Architecture of fault-tolerant computers; Fault-tolerant multiprocessors and distributed systems principles; Various concepts of operating system; Study of fault-tolerance in softwares; Introduction to the concept of system diagnosis.

Suggested Books:

1. Daniel P. Siewiorek and R.S. Swarz , Reliable Computer Systems Design and Evaluation, AK Peters Ltd,1998.
2. D.K. Pradhan, Fault-Tolerant Computing: Theory and Techniques Vol. I,II, Prentice-Hall, 1986.
3. B.W.Johnson, Design and Analysis of Fault Tolerant Digital System, Addison-Wesley, 1989.

Elective 8

VLS6301 Speech Processing

Speech signal: production, perception, acoustic- phonetic characterization, signal processing methods for speech recognition, pattern- comparison techniques, speech recognition system design and implementation issues, speech recognition based on connected word models, task oriented applications of automatic speech recognition.

Suggested Books:

1. L. Rabiner and B. H. Juang, Fundamentals of speech recognition, Prentice Hall, 1993.

VLS6303 Embedded Automotive systems

Automotive Architectures: Vehicle Functional Domains and Their Requirements, Application of the AUTOSAR Standard Intelligent Vehicle Technologies ,**Embedded Communications:** A Review of Embedded Automotive Protocols, FlexRay Protocol, Dependable Automotive CANs, **Embedded Software and Development Processes:** Product Lines in Automotive Electronics, Reuse of Software in Automotive Electronics, Automotive Architecture Description Languages, Model-Based Development of Automotive Embedded Systems, **Verification, Testing, and Timing Analysis:** Testing Automotive Control Software, Testing and Monitoring of FlexRay-Based Applications, Timing Analysis of CAN-Based Automotive Communication Systems, Scheduling Messages with Offsets on Controller Area Network—A Major Performance Boost, Formal Methods in the Automotive Domain: The Case of TTA

Suggested Books

1. N. Navet and F.S. Lion, Automotive Embedded Systems Handbook 1st Edition, CRC Press, 2008.
2. T. Weather Jr. and C.C. Ilunter, Automotive computers and control system, Prentice Hall Inc., 1984.
3. W. Ribbens, Understanding Automotive Electronics, Butterworth-Heinemann, 2012.

VLS6305 Machine Learning

Introduction to Machine Learning: Learning Associations; Classification, Regression, Annotation, Supervised Unsupervised, Semi supervised, learning Basic tools: Linear classification, regression, Feature maps, Trees, Instance based classifiers. Supervised Learning, Vapnik - Chervonenkis Dimension, Probably Approximately Correct Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm. Decision Tree Learning, Linear Discrimination: Reinforcement Learning ,Single State Case: K-Armed Bandit, Elements of Reinforcement Learning, Model-Based Learning Value Iteration Policy methods Policy evaluation Policy iteration Policy gradient Policy Iteration Temporal Difference Learning Exploration Strategies Deterministic Rewards and Actions Nondeterministic Rewards and Actions Eligibility Traces.

Suggested Books:

1. E. Alpaydin, Introduction to machine learning, MIT Press, 2004
2. S. Roger and M. Girolami, A first course in machine learning, CRC Press, 2016

VLS6307 Advanced Computer Architecture

Parallel Computer Models, Program and Network Properties, System Interconnect Architecture, Advanced processor technology, Instruction-set architectures, CISC Scalar processors, RISC, Scalar processors, Superscalar processors, VLIW architectures, Vector and symbolic processors. Memory Hierarchy, Cache basics & cache performance, Reducing miss rate and miss penalty, Multilevel cache hierarchies, Main memory organizations, Design of memory hierarchies. Symmetric shared memory architectures, Distributed shared memory architectures, Models of memory consistency, Cache coherence protocols (MSI, MESI, MOESI), Scalable cache coherence, Overview of directory based approaches, Design challenges of directory protocols,

Memory based directory protocols, Cache based directory protocols, Protocol design tradeoffs, Synchronization.

Suggested Books:

1. K. Hwang, Advanced computer architecture, McGraw Hill, 2010.
2. D. A. Patterson and J. L. Hennessey, Computer organization and design, Morgan Kaufmann, 2nd Ed, 2010.
3. J. P. Hayes, Computer Architecture and Organization, McGraw Hill, 2017.

VLS6309 Embedded Software

Embedded software, features, design patterns for embedded software, models of computation, assemblers, interpreters, compilers, C in embedded environment, high level embedded programming languages, Optimization of execution time, energy and power, program size. Program validation and testing, embedded operating system, processes,

context switching, scheduling policies, inter process communication, power optimization strategies, Real time OS, distributed embedded systems.

Suggested Books:

1. C. Walls, Embedded Software: The Works, Newness, 2012.
2. K. Qian, D.D. Haring and Li Cao, Embedded Software Development with C, Springer, 2009.

VLS6311 Phase Locked Loop Design

Phase locked loops' requirements, Integer/ fraction-N PLLs, delay locked loops, injection locked loops, sub-sampled PLLs, Building Blocks- Phase/ frequency detectors, charge pumps, LC/ ring oscillators, multi modulus frequency dividers, Active/ passive loop filters.

Suggested Books:

1. R. Best; Phase-Locked Loops, McGraw Hill, 2007.
2. C. Quemada, G. Bistue and I. Adin; Design Methodology for RF CMOS Phase Locked Loops, Artech House, 2009.

VLS6201 VLSI signal processing architecture

Introduction to DSP Systems: Introduction; representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph. Iteration Bound: Data flow graph representations, loop bound and iteration bound, longest path matrix algorithm, iteration bound of Multirate data flow graphs. Pipelining and Parallel Processing: Pipelining and parallel processing of FIR digital filters, pipeline interleaving in digital filters: signal and multichannel interleaving. Retiming, Unfolding and Folding: retiming techniques; algorithm for unfolding, Folding transformation, systolic architecture design, systolic array design methodogy. Fast Convolution, Filters and Transforms: Cook-toom algorithm, modified cooktoom algorithm, winogard algorithm, iterated convolution Algorithm strength reduction in filters and transforms.

Suggested Books:

1. K.K. Parhi, VLSI Digital Signal Processing Systems: Design and Implementation, John Wiley & Sons, 1999.
2. Richard J and Higgins, Digital Signal Processing in VLSI, Prentice Hall, 1991.
3. M.A. Bayoumi, VLSI Design Methodology for DSP Architectures, Kluwer, 1994.
4. U. Meyer – Baese, Digital Signal Processing with FPGAs, Springer, 2004.

VLS6203 FPGA based soft computing

FPGA neurocomputers, FPNA:Applications and implementations, FPGA implementation of very large associative memories, FPGA implementation of neocognitrons, implementation of fully and partially connected MLP, FPGA implementation of non-linear predictors, implementation of self-organizing feature maps in reconfigurable hardware.

Suggested Books:

1. N. Nedjah and L. de M. Mourelle, Hardware for Soft Computing and Soft Computing for Hardware, Springer, 2013.
2. A.R. Omondi and J.C. Rajapakse, FPGA implementation of neural networks, Springer, 2005.

VLS6205 Selected topics in embedded systems

From Research papers

VLS6207 Selected topics in VLSI

From research papers.

Semester IV

VLS652 Research Project

VLS602 Major Project II

DEPARTMENT OF ELECTRICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Control & Instrumentation)

Programme Specific Outcomes

1. To be able to apply the knowledge of Electrical Engineering fundamentals to the solution of complex problems in advanced Instrumentation and Control System.
2. To be able to design system components or processes that meet the specified needs with appropriate considerations for the public health, safety and culture, societal and environmental considerations.
3. To be able to crate, select and apply modern techniques resources and modern engineering and IT tools including simulation and modeling of modern Instrumentation and Control of Processes.
4. To be able to understand, analyze and demonstrate the principles of engineering and apply these ones to carry out the advanced research projects.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN CONTROL & INSTRUMENTATION (C&I)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester-I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	C&I 501	System Theory	Core	4	3	0	2	15	25	20	40	-	17
	2	C&I 503	Measurement & Instrumentation	Core	4	3	0	2	15	25	20	40	-	
Group B	3	C&I 5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	C&I 5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	C&I 5201/5203/.../	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester-II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C 2	1	C&I 502	Intelligent Control	Core	4	3	0	2	15	25	20	40	-	17
	2	C&I 504	Process Control	Core	4	3	0	2	15	25	20	40	-	
Group D 4 5	3	C&I 5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	C&I 5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	C&I 5202/5204/.../ UEC 5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester-III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	C&I 651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	C&I 601	Major Project-1	Core	3					40	0	60		12
	2	C&I 6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	C&I 6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	C&I 6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester-IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group F	1	C&I 652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	C&I 602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	C&I 5401	Analog and Digital Electronics	Elective	4	3	0	2	15	25	20	40	-
	2	C&I 5403	Manufacturing, Automation & Control		4	3	0	2	15	25	20	40	-
	3	C&I 5405	Biomedical Instrumentation		4	3	0	2	15	25	20	40	-
	4	C&I 5407	Soft Computing Techniques		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	C&I 5301	Random Processes in Control & Estimation	Elective	3	3	0	0	20	-	30	50	-
	2	C&I 5303	Nonlinear Control Theory		3	3	0	0	20	-	30	50	-
	3	C&I 5305	Design of Fractional Order Systems		3	3	0	0	20	-	30	50	-
	4	C&I 5307	Optimization Techniques		3	3	0	0	20	-	30	50	-
	5	C&I 5309	Applied Mathematics										
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	C&I 5201	Seminar	Elective	2	2	0	0	0	100	-	-	-
Elective 3	2	C&I 5203	Bio Engineering & Control		2	2	0	0	20	-	30	50	-
	3	C&I 5205	Networked Control System		2	2	0	0	20	-	30	50	-
	4	C&I 5207	Robust Control		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	C&I 5402	Intelligent Instrumentation	Elective	4	3	0	2	15	25	20	40	-
	2	C&I 5404	Digital Signal Processing		4	3	0	2	15	25	20	40	-
	3	C&I 5406	Power Quality		4	3	0	2	15	25	20	40	-
	4	C&I 5408	Modelling, Identification and Control		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	C&I 5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	C&I 5304	Computer Communication & Control		3	3	0	0	20	-	30	50	-
	3	C&I 5306	Analog Filter Design		3	3	0	0	20	-	30	50	-
	4	C&I 5308	Optimal Control Theory		3	3	0	0	20	-	30	50	-
	5	C&I 5310	Digital Image Processing										

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	C&I 5202	Nature Inspired Algorithms	Elective	2	2	0	0	20	-	30	50	-
	2	C&I 5204	Adaptive Signal Processing		2	2	0	0	20	-	30	50	-
	3	C&I 5206	Machine Learning		2	2	0	0	20	-	30	50	-
	4	C&I 5208	Special Topics in Control Systems		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	C&I 6401	SCADA & Energy Management	Elective	4	3	0	2	15	25	20	40	-
	2	C&I 6403	Applications of Control in Power Electronic Systems		4	3	0	2	15	25	20	40	-
	3	C&I 6405	Microcontroller & Embedded Systems		4	3	0	2	15	25	20	40	-
	4	C&I 6407	Digital Instrumentation		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	C&I 6301	Robot Dynamics & Control	Elective	3	3	0	0	20	-	30	50	-
	2	C&I 6303	Stochastic Control		3	3	0	0	20	-	30	50	-
	3	C&I 6305	Adaptive Control		3	3	0	0	20	-	30	50	-
	4	C&I 6307	Instrumentation Transducers		3	3	0	0	20	-	30	50	-
	5	C&I 6309	Advanced Control System Design		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	C&I 6201	Special Topics in Instrumentation	Elective	2	2	0	0	20	-	30	50	-
	2	C&I 6203	Special Topics in Signal Processing		2	2	0	0	20	-	30	50	-
	3	C&I 6205	Digital Communication		2	2	0	0	20	-	30	50	-
	4	C&I 6207	Pattern Recognition		2	2	0	0	20	-	30	50	-
	5	C&I 6209	Artificial Intelligence		2	2	0	0	20	-	30	50	-

Semester I

Courses

C&I 501 System Theory

Concept of state, state variable and sate vectors. State variable modelling of continuous and discrete time systems. Discrete time response of sampled- data control systems, Z-Transform and its properties, Jury's stability test, stability via Z-plane and bi-linear transformation. Phase variable, canonical variable forms, evaluation and properties of state transition matrix, solution of state equations of linear time invariant and time variant continuous and discrete time systems. Stability in the sense of Lyapunov, asymptotic stability of LTI continuous and discrete time systems. Solution of Lyapunov equation. Concepts of controllability and observability, controllability, observability tests, observer design, observer based controller design reduced order observer design. Pole assignment by state feedback using Ackermann's formula.

Suggested Readings:

1. J.P. Hespanha, '' Linear Systems Theory", Second Edition, Princeton University Press, 2018.
2. C. T. Chen,'' Linear System Theory and Design", Third Edition, Oxford University Press.
3. M. Gopal, "Digital Control and State Variable Methods", McGraw Hill Education (India) Private Limited, 2015.
4. P.J. Antsaklis and Anthony N. Michel, "A Linear Systems Primer", Birkhauser, 1997.
5. R. W. Brockett, "Finite Dimensional Linear Systems", John Wiley and Sons, 1970.
6. T.M Apostol, "Mathematical Analysis", Second Edition, Narosa Publishing House, 1996.
7. Michael Spivak, "Calculus on Manifolds: A Modern Approach to Classical Theorems of Advanced Calculus", CRC Press, 1971.
8. P.R. Halmos, D Van Nostrand Company, "Finite-dimensional Vector Spaces", Princeton University Press, 1942.

C&I 503 Measurement & Instrumentation

Measurement system architecture, errors in measurements, standards. Potentiometers, AC null measurements, The Anderson constant current loop. AC operation of Wheatstone bridges, AC bridges.Resistive sensors, voltage generating sensors, sensors based on variable magnetic/ capacitive coupling, capacitance sensor. Measurement of linear/angular displacement /velocity / acceleration. Angular velocity measurement with mechanical gyroscopes, measurement of force and torque. Analog signal conditioning using linear and non-linear electronic circuits, Differential amplifiers, instrumentation amplifiers, Nonlinear analog signal processing by Op-amps and by special function modules. Measurement of nonelectrical quantities like: pressure, vacuum, flow, thickness, pH, sound. Measurement of power and energy using digital techniques. Digital interface in measurement system: The IEEE-488 instrumentation bus, serial data communications Links. DC and AC telemetering systems

Suggested Readings:

1. R.B. Northrop, "Introduction to Instrumentation and Measurements", Third Edition, CRC Press, 2014.
2. E.O. Doebelin, "Measurement Systems- Application and Design", Fifth Edition, Mc-Graw Hill, 2004.

3. B.M. Oliver and J.M. Cage, "Electronic Measurements and Instrumentation", Second Edition, Oxford Higher Education, 2009.

C&I 502 Intelligent Control

Norms of signals, vectors and matrices, positive definite, negative definite, positive semi definite and negative semi definite functions. Nonlinear control strategies, State feedback linearization systems. Fuzzy logic control using Mamdani model. Implementation of fuzzy logic controller using MATLAB fuzzy-logic toolbox. Stability analysis of fuzzy control systems. Neural Networks in system identification and control control of non linear system using neural network toolbox, inverse neural network control, and adaptive control using neural networks.

Suggested Readings:

1. B. Kosko, "Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence", First Edition, Prentice-Hall of India Pvt. Ltd, 1991.

2. J.S.R Jang, C.T. Sun, E. Mizutani, "Neuro-fuzzy and soft Computing", First Edition, Pearson Education, 1997.

3. L. Behera, I. Kar, "Intelligent Systems and Control", Oxford Higher Education, 2009.

4. Omid Omidvar and L. Elliott David, "Neural Systems for control", First Edition, Academic Press Limited, 1997.

5. C.T. Lin and C.S.G. Lee, "Neural Fuzzy Systems", First Edition, Prentice Hall PTR, 1996.

C&I 504 Process Control

Introduction to process control, models of industrial process, hydraulic tanks, fluid flow systems, mixing process, chemical reactions, thermal systems-heat exchangers and distillation column. Basic control action-on/off, P, P+I, P+I+D, floating control, pneumatic and electronic controllers, controller tuning, time response and frequency response methods , non-linear controllers, inverse time response of system, effect of pole and Zero on right hand side of s- plane, feed forward and multivariable control. Evolution of PLC, sequential and programmable controllers, architecture, Programming of PLC, relay logic and ladder logic, functional blocks, communication networks for PLC, field bus such as profi-bus, mod-bus etc.

Suggested Readings:

1. Stephanopolus George, "Chemical Process control: An Introduction to Theory and Practice", First Edition, Prentice Hall India, 1983.

2. P. Harriot, "Process control", Tata McGraw-Hill, 2012.

3. Norman A Anderson, "Instrumentation for process measurement and control", Third Edition, CRC Press LLC, 1998.

4. Dale E. Seborg, Thomas F Edgar, Duncan A Mellichamp, "Process dynamics and control", Third Edition, Wiley John and Sons, 2011.

5. T.E. Marlin, "Process control", Second edition, McGraw hill, 2000.

6. M.P Lucas, "Distributed Control System", First Edition, Van Nostrand Reinhold Co. 1986.

7. Pertrezeulla, "Programmable Controllers", Fourth Edition, McGraw-Hill, 2016.

C&I 5401 Analog and Digital Electronics

Linear circuits: basic circuits like non-inverting/inverting amplifiers, differential and instrumentation amplifiers, integrator, practical integrators using non- ideal model of opamps, current sources for floating and grounded loads, negative impedance converter, generalized impedance converter. Real opamp performance parameters, static limitations, dynamic limitations, input-output swing limitations, compensation techniques. Applications in Non-linear circuits, Comparators, Schmitt trigger, precision rectifier. log/antilog amplifiers, analog multipliers. Operational transconductance amplifiers and their applications. Combinational circuits, Latches, racing, master salve flip-flops, characteristic equations, sequential circuits.

Suggested Readings:

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", Third Edition, Tata McGraw-Hill, 2017
2. George Clayton and Steve Winder, "Operational Amplifiers", Fifth Edition, EDN Series foe design Engineers, 2003.
3. John F. Wakerly, "Digital design", Fourth Edition, Prentice Hall, 2000.
4. Sedra and Smith, "Microelectronic circuits", Seventh Edition, Oxford Publication, 2017.
5. Donald A Neamen, "Electronic circuit analysis and design", Third Edition, Tata McGraw-Hill, 2006.
6. Ramon Pallas Areny, "Analog signal processing", Wiley Publications, 2011.

C&I 5403 Manufacturing, Automation & Control

Production Operations and automation strategies, production economics, high volume production systems. Numerical control, DNC, CNC and adaptive control industrial robotics and applications, sequence control, computer control, CAD/CAM. Intelligent system architecture, design technique, knowledge based system, artificial neural network, fuzzy system, genetic algorithms in process planning, scheduling, fault diagnosis, automated assembly, manufacturing feature identification, process monitoring and control.

Suggested Readings:

1. Miller P. Groover, "Automation production systems, and computer integrated Manufacturing", Third Edition, PHI, 2008.

C&I 5405 Biomedical Instrumentation

Basic concepts of Bio-medical instrumentation, terminology, generalized medical instrumentation system, measurement constrains, classification, Interfacing and modifying inputs, Bio statistics, static and dynamic characteristic, regulation of medical devices, electrical safety in medical environment. Basic sensors and signal processing, displacement measurements, resistive sensors, bridge circuits, inductive, capacitive and piezo electric sensor, temperature measurements, thermocouples radiation thermometry fiber optic temperature sensors, optical measurements, opamp circuits, Microcomputers in bio-medical instrumentation. Bio potentials and measurements, electric activity and excitable cells. Functional organization of peripheral nervous system. ENG, EMG, ECG, EEG & MEG, Bio-potential electrodes, electrolyte interface. Bio potential amplifiers. Direct and indirect blood pressure measurement and analysis

Suggested Readings:

1. Khandpur R.S., "Handbook of Bio-medical Instrumentation", Third Edition, Tata McGraw-Hill, 2014.
2. Dean D.E., Marre A., "Bio electronic Measurements", Prentice Hall.
3. A li Evans, "The Evaluation of Medical Images", First Edition, CRC Press, 1981.
4. John G. Webster, "Medical Instrumentation application and design", Fourth Edition, John Wiley and Sons, 2009.
5. L. Cromwell., Fred J. Weibell, "Bio medical Instrumentation and measurements", Second Edition, Prentice Hall, 1990.

C&I 5407 Soft Computing Techniques

Introduction to crisp set and fuzzy sets, Operations on fuzzy sets. Fuzzy relations, fuzzy measures, fuzzy rules, membership functions, rule base, fuzzy models. Introduction to neural network, Learning schemes, supervised, unsupervised learning, incremental and batch training, backpropagation algorithm, the perceptron neural network, multilayer perceptron, radial basis function networks, self-organizing map, recurrent neural network, Elman networks, Jordan networks etc., Neuro-dynamics, applications of neural network. Basic concept of Genetic algorithm and detailed algorithmic steps. Solution of typical control problems using genetic algorithm. Concept of some other search techniques like tabu search and ant-colony search, biography based optimization techniques for solving optimization problems.

Suggested Readings:

1. D.K Pratihar, "Soft Computing Techniques", First Edition, Alpha Publications, 2013
2. Jacek M. Zuarda, "Introduction to Artificial Neural Systems ", Jaico Publishing House, 1997.
3. Sudarshan K. Valluru, T.N Rao, "Neural Networks, Fuzzy Logic and Genetic Algorithms", First Edition, Jaico Publishing House, 2010.
4. G.J. Klir & T.A. Folger, "Fuzzy sets, uncertainty and information", First Edition, Prentice-Hall of India, 1988.
5. H.J. Zimmerman, "Fuzzy set theory-and its Applications", Fourth Edition, Kluwer Academic Publishers, 2001.
6. Driankov, Hellendron, "Introduction to Fuzzy Control", Second Edition, Narosa Publishers, 1996.

C&I 5301 Random Processes in Control & Estimation

Random variables and processes, Weiner's theory of optimization. Basic concepts of estimation and various types of estimates, applications of Weiner's theory of compensator design for feedback control system. Gauss-Markov model for vector random Processes, Kalman filtering, minimum variance Introduction, Statement of optimal control problem-Problem formulation and forms of optimal control-Selection of performance measures.

Suggested Readings:

1. D.E. Kirk, "Optimal Control Theory: An Introduction", First Edition, Dover Publications Inc., 2004
2. A.P. Sage, "Optimum System Control", Second Edition, Prentice Hall, 1997.

3. BD.O. Anderson and J.B. Moore, "Optimal Filtering", Second Edition, Dover Publications, 2005.

4. S.M. Bozic, "Digital and Kalman Filtering", First Edition, Edward Arnould, London, 1979.

5. K.J. Astrom, "Introduction to Stochastic Control Theory", 56.52 Edition, Academic Press, 2006.

C&I 5303 Nonlinear Control Theory

Introduction to non-linear systems and their behavior, multiple equilibrium points, limit cycles. nonlinear system analysis, phase-plane analysis, isoclines method and delta method. Concept of singular points and their analysis, existence of limit cycles. Describing function analysis, describing function of common non-linearities. Stability analysis of nonlinear system using describing function, dual input describing function, perturbation theory and perturbation dynamics. Lyapunov's methods, krasovski method, variable gradient method. Advanced stability criterion, Lyapunov analysis of non-autonomous systems. Lyapunov's direct method of stability, absolute stability and Popov's criterion.

Suggested Readings:

1. D.P. Atherton, "Nonlinear control Engineering", First Edition, Van Nostrand Reinhold, 1975.

2. D.P. Atherton, "Stability of Nonlinear system", First Edition, John Wiley & Sons, 1981.

3. W.J. Cunningham, "Introduction to Nonlinear Analysis", First Edition, McGraw-Hill, 1958.

4. J.E. Gibson, "Nonlinear, Automatic Control", First Edition, Tata McGraw-Hill, 1964.

5. W. Hahn, "Theory and Application of Lyapunov's Direct Method", First Edition, Prentice-Hall, Englewood Cliffs, 1963.

6. R.R. Mohler, "Nonlinear Systems: Dynamics and Control", Prentice-Hall, Englewood Cliffs, 1990.

7. Mark W. Spong, and M. Vidhyasagar, "Robotic Dynamics and Control", Prentice Hall, Englewood Cliffs, 2008.

8. M. Vidhasagar, "Nonlinear System Analysis", Second Edition, Prentice-Hall, Englewood Cliffs, 2002.

C&I 5305 Design of Fractional Order Systems

Fundamentals of fractional order systems, different methods for approximating the fractional operator, analog circuit implementation of fractional order circuit elements. Fractional order analog circuits and filters of different types. Fundamentals of fractional order control, fractional-order PID controllers. Tuning of first-order plus delay time plants, fractional-order PD controller tuning for motion systems, tuning of fractional-order lead-lag compensators, Auto-tuning of Fractional-order Lead-lag Compensators.

Suggested Readings:

1. C.A. Monje , Y. Chen, B.M. Vinagre, D. Xue, V. Feliu-Batlle, "Fractional-order Systems and Controls", Springer, 2010.

2. A. Tepljakov, "Fractional-order Modeling and Control of Dynamic Systems" Springer, 2017.

C&I 5307 Optimization Techniques

Linear Programming, Simplex algorithm, two phase and big M Techniques. Duality theory, simplex method, integer programming and dynamic programming. Non linear programming ,Kuhn Tucker conditions ,formulation of dynamic programming, forward and backward recursive equation, computational procedures. One dimensional minimization methods, unconstrained minimization techniques, direct search methods, steepest descent method, conjugate gradient method and Newton's method. Constrained optimization direct & indirect methods. CPM, PERT and Quadratic programming.

Suggested Readings:

1. S.S.L. Chang, "Synthesis of Optimal Control", First Edition, Tata McGraw-Hill, 1961.
2. D.E. Kirk, "Optimal Control Theory: An Introduction", First Edition, Dover Publications Inc., 2004.
3. M. Athans and P.L. Falb, "Optimal Control: An Introduction to the Theory and its Applications", Third Edition, McGraw-Hill, 2007.
4. A.P. Sage, and C.C. White, III, "Optimum System Control", Second Edition, Prentice-Hall, Englewood Cliffs, 2001.

C&I 5309 Applied Mathematics

Review of sets, relations and mappings, Boolean algebra, and laws of probability. Bayes theorem. Random variable, Expectation, Moments and covariance. Probability as a set function. Second order random functions, Gaussian random functions. Poisson process, Markov Chain, Auto/cross correlation . Linear vector spaces over a field subspace, bases, dimension and linear transformations. Quadratic forms. Eigen,values using QR transformations, generalized Eigen vectors, canonical forms, singular value decomposition and applications, pseudo inverse. Solution of non linear differential equations. Finite differences and finite element. Calculus of variations. concept of variation and its properties, finite differences and finite elements methods. Euler's equation, functional dependant on first and higher order derivatives, functional dependants on functions of several independent variables, variation problems with moving boundaries, isoperimetric problems, direct method, Ritz and Kantorovich methods.

Suggested reading:

1. R. Bronson, "Matrix Operations", Schaum's outline series, McGraw Hill, New York.
2. A.S. Gupta, "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi.
3. H.A. Taha, Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi.
4. M.K Ochi, "Applied Probability and Stochastic Processes", John Wiley and sons.

C&I 5203 Bio Engineering & Control

Basic components of bio-medical instruments, bio-electric signals & recording electrodes, transducers, recording and display devices. Patient care and monitoring systems, cardiovascular measurements-blood pressure, blood flow, cardiac output, and heart sounds etc. Instrumentation for respiratory and nervous systems, analysis of EEG, ECG, EMG, EOG and action potentials, non-invasive diagnostic measurements- temperature, ultrasonic diagnosis, CAT scan techniques, sensory measurements motor response, analysis of behavior etc. biotelemetry, biofeedback, clinical laboratory instruments

and X-ray diagnosis. Recent advances in biomedical instrumentation microprocessor based system, lasers & optical fiber based systems.

Suggested Readings:

1. R. S. Khandpur, "Handbook of Analytical Instruments", Third Edition, Tata McGraw-Hill, 2015.
2. D.E. Dean, A. Marre, "Bio-Electronic Measurements", First Edition, Prentice Hall, 1983.
3. A li Evans, "The Evaluation of Medical Images", First Edition, CRC Press, 1981
4. John G. Webster, "Medical Instrumentation application and design", Fourth Edition, John Wiley and Sons, 2009.
5. L. Cromwell., Fred J. Weibell, "Bio medical Instrumentation and measurements", Second Edition, Prentice Hall, 1990.

C&I 5205 Networked Control System

Overview of Networked Control System (NCS), Communication Systems Models, Control Systems Models, Models of NCS, Applications, Analysis and design of simple NCS, Discussion and analysis of current state-of-the-art approaches in NCSs, Trends in NCS.

Suggested Readings

1. Analysis and Design of Networked Control Systems (Chapters 1-8)
2. Communication and Control for Networked Complex Systems (Chapters 1,2)
3. Distributed Decision Making and Control (Chapter 3)
4. [Journal paper] The Wireless Control Network- A New Approach for Control Over Networks
5. Handbook of Networked and Embedded Control Systems (Parts I,IV)

C&I 5207 Robust Control

Classical control, root locus, Nyquist plots, robustness and disturbance rejection in SISO systems. multivariable linear systems, continuous time state space models, discrete time state models. Transfer functions, frequency response, poles, zeros and modes. Stability, change of basis, controlloability observability and observer feedback. Performance measures. general models of feedback control systems. Norms and cost functions. Robustness, internal stability, structured and unstructured uncertainty models and their robustness analysis.H∞ control, full information control, H∞ estimation, h∞ output feedback, finite time control, steady state control and μ synthesis.

Suggested Readings:

1. J. B. Burl, Linear Optimal Control H2 and H∞ Methods, Addison Wesley, California, US.1999.
2. 2. K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, 1999.
3. S. Skogstad and I. Postlethwaite, Multivariable Feedback Control, John Wiley and Sons, 2005.
4. T. Glad and L. Ljung, Control Theory: Multivariable and Non-linear methods, Taylor and Francis, London, 2009.

Semester II

C&I 5402 **Intelligent Instrumentation**

Background of Instrumentation: Process and Process. Parameters, Classical Sensors and Transducers, Self-Generating Transducers, Variable Parameter Transducers, Radioactive Transducer, Semiconductor Sensors, Array-Based Sensors, Biosensors, Actuating Devices. **Sensor Performance Characteristics:** Static Characteristics, Dynamic Characteristics, Input–Output Impedances. **Signals and System Dynamics:** Signal Representation, Test Signals, Spectral Density and Correlation Function, Modifying and Modulating Input, Compensation Techniques, System Dynamics. **Intelligent Sensors:** Smart Sensors, Cogent Sensors, Soft or Virtual Sensors, Self-Adaptive Sensors, Self-Validating Sensors, VLSI Sensors, Temperature Compensating Intelligent Sensors, Indirect Sensing. **Sensors with Artificial Intelligence:** Artificial Intelligence, Multi-dimensional Intelligent Sensors, AI for Prognostic Instrumentation, ANN-Based Intelligent Sensors, Fuzzy Logic–Based Intelligent Sensors. **Intelligent Sensor Standards and Protocols:** IEEE 1451Standard, Network Technologies, Plug-n-Play Smart Sensor Protocol.

Suggested Readings:

1. Intelligent Instrumentation Principles and Applications Manabendra Bhuyan CRC Press Taylor & Francis Group, 2011.
2. Smart Sensors, Measurement and Instrumentation, Subhas Chandra Mukhopadhyay, Springer-Verlag Berlin Heidelberg 2013
3. Smart Sensor Systems, Gerard C.M. Meijer John Wiley & Sons 2008.

C&I 5404 **Digital Signal Processing**

Discrete Time Signals and Systems, Representation of discrete time signals- classifications-Discrete time systems, Discrete Fourier transform properties. Fast Fourier transform- Z- transform, structure realization, direct form- lattice structure for FIR filter- Lattice structure for IIR Filter. Design of Filters, FIR Filter- windowing technique- optimum equiripple linear phase FIR filter- IIR filter- Bilinear transformation technique- impulse invariance method- Butterworth filter- Tchebyshev filter. Multistage representation, Sampling of band pass signal- antialiasing filter – Decimation by an integer factor- interpolation by an integer factor- sampling rate conversion – implementation of digital filter banks- sub-band coding- Quadrature mirror filter

Digital Signal Processors, Fundamentals of fixed- and floating-point DSP architecture.

Suggested Readings:

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorthms and Applications", Fourth Edition, PHI, 2007.
2. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing" TMH, 2000.
3. A.V. Oppenheim and R.W. Schafer, Englewood "Digital Signal Processing", First Edition, Prentice-Hall, 1975.
4. Rabiner and Gold, "Theory and Application of Digital Signal Processing", First Edition, 2015
5. B. Venkatramani & M. Bhaskar, "Digital Signal Processors architecture, programming and applications", Tata Mc Graw Hill, 2015.

C&I 5406 Power Quality

Classification of power quality issues, characterization, power acceptability curves. Power quality problems, poor load power factor, Non-linear and unbalanced loads, DC offset, notching, disturbance, flicker, transients, voltage fluctuations, sags/swells/unbalance, Power quality indices, recommended practices, Influence of Non-Sinusoidal Conditions: transmission and distribution, resonance, shunt capacitors, transformers inrush currents, electric machines, ground systems. voltage, current, power and energy measurements, power factor measurement,. Analysis in the periodic steady state, time domain method, frequency domain methods, IRPT, SRF theory, instantaneous symmetrical components, analysis of unbalanced systems, analysis and reduction of voltage sag, harmonics & voltage fluctuations: Sources and effects, flicker, impulses, occurrence and causes of voltage unbalance, symmetrical components. Utility- customer interface,-harmonic filter, load compensation and voltage regulation using DSTATCOM, uninterruptible power sources, BESS, DVR, UPQC.

Suggested reading:

1. A. Ghosh and G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Acadamic.
2. G.T. Heydt. "Electric Power Quality", Stars in a Circle Publications (2nd Edition).
3. J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment, John Wiley & sons, New York.
4. Math H.J. Bollen, Understanding Power quality problems, IEEE Press, New York.
5. E. Acha, Manuel Madrigal, Power system Harmonics, John Wiley & sons, New York.
6. Moreno – Murioz (Ed), Power Quality (Mitigation Technologies in Distribution Environment Springer, 07.

C&I 5408 Modelling, Identification and Control

Random variables and process, stochastic processes, properties, mean, variance, correlation, spectral density. Problem formulation for identification & estimation. Review and realization of continuous and discrete, state space and input-output, disturbance models, inverse response system dynamics. Parameter estimation, linear regression models, multiple regression model, ARMA models, experimental techniques. Online identification techniques, development of 'Least Squares' regression, exponentially mapped estimates. Discrete design methods, Functional models of computer process control systems, RTOS, input-output systems, functions of the computer process control system, techniques for developing physical process models, Position, velocity, dead beat, ringing and Dahlin algorithms.

Suggested Readings:

1. Ljung, "System Identification theory for the user", Fifth Edition, Prentice Hall of India, 2001.
2. Rolf. Johansson, "System Modelling and Identification", First Edition, Prentice Hall of India, 1993.
3. Astrom and Wittenmark, "Adaptive Control", Second Edition, Prentice Hall of India, 1995.
4. Willam S.Levine, "Control Hand Book", Second Edition, CRC Press, 2010.
5. Narendra and Annasamy, "Stable Adaptive Control System", Dover Publications, 2005.

C&I 5304 Computer Communication & Control

Line diagram from process plant to computer system, loose coupled system and Tight coupled system, communication media and bus. Protocol and Architectures, evolution of data networks, network architecture. Protocols, layered approach, OSI model, DoD model hierarchical approach, Local network technology- Bus/Tree topology-ring topology-medium access protocols-Details of IEEE 802, X.25, datagram, HDLC standards. Network access protocol & internetworking, circuit switched network access, packet switched network access, Broadcast network access, principle of internetworking, bridges, gateways-X, and 75-internet protocols, ISO internet protocol standard. Compression techniques and cryptography, Application of computer communication for control functions, application of soft computing for control functions.

Suggested Readings:

1. Andrew S. Tanenbaum, "Computer Networks", Fifth Edition, Pearson, 2010.
2. Achyut S. Godbole, "Data Communications and Networking", Second Edition, Tata McGraw Hill, 2017.
3. W. Stallings, "Data and Computer Communication", Tenth Edition, Edition, Macmillan, 2013.

C&I 5306 Analog Filter Design

First order filters, Realization with passive elements, realization with active elements, cascaded design, Second order LP and BP filters, design parameters, the 2nd order circuits, KHN, Bi quads, S & K Biquads, SAB biquads and GIC circuits. LP filters with maximally flat and equal ripple response, inverse Chebyshev and Cauer filter. Frequency transformation: LP-HP, LP-BP, LP-BE, etc. LC- Ladder filters, Ladder Simulation by element replacement, GIC embedding technique, FDNR technique, creation of negative components, Gm-C & switched capacitor filters, Introduction to modern active building blocks used in analog signal processing.

Suggested Readings:

1. R. Schaumann and M.E. Vanvalkenburg, "Design of Analog Filters", First Edition, Oxford, 2001.
2. Raj Senani, D.R. Bhaskar and A.K. Singh, "Current Conveyers, Variants, Applications and Hardware Implementation" Springer, 2015.

C&I 5308 Optimal Control Theory

Introduction, statement of optimal control problem, problem formulation and forms of optimal control, selection of performance measures. necessary conditions for optimal control , Pontryagin's minimum principle,state inequality constraints, minimum time problem. LQ control problems anddynamic programming. Linear optimal regulator problem, matrix Riccatti equation and solution method, linear tracking problem, – LQG problem, dynamic programming, application to discrete and continuous systems, – Hamilton Jacobi Bellman equation, numerical Techniques for Optimal Control.

Suggested Readings:

1. D.E. Kirk, "Optimal Control Theory: An Introduction", First Edition, Dover Publications Inc., 2004
2. A.P. Sage, "Optimum System Control", Second Edition, Prentice Hall, 1997.
3. BD.O. Anderson and J.B. Moore, "Optimal Filtering", Second Edition, Dover Publications, 2005.
4. S.M. Bozic, "Digital and Kalman Filtering", First Edition, Edward Arnould, London, 1979.
5. K.J. Astrom, "Introduction to Stochastic Control Theory", 56.52 Edition, Academic Press, 2006.

C&I 5310 Digital Image Processing

Elements of visual perception, digital Image, connectivity and relations between pixels. Simple Operations ,viz. arithmetic, logical and geometric. Mathematical Preliminaries, 2D linear space invariant Systems, 2D convolution, correlation 2D random sequence, 2D Spectrum. Image transforms, 2D orthogonal and unitary transforms, properties. 2D DFT, FFT, DCT, Hadamard transform, Haar transform, KL transform. Image enhancement, histogram equalization technique, point processing, spatial filtering in space and frequency. Nonlinear filtering. Image restoration, image observation and degradation model, circulant and block circulant matrices. Algebraic approach to restoration, inverse by Wiener filtering, generalized inverse, SVD and interactive methods. Image compression, redundancy and compression, variable-length Huffman coding, arithmetic coding, bit-plane coding, loss less predictive coding, lossy transform (DCT) based coding, JPEG standards band coding

Suggested Readings:

1. R.C Gonzalez & R.E Woods, "Digital Image Processing", Third Edition, Pearson Education, 2008.
2. Kenneth R. Castleman, "Digital Image Processing", First Edition, Pearson Education,1995.
3. S. Jayaraman, S. Esakkirajan, T. Veerakumar, "Digital Image Procesing", First Edition, McGraw Hill Education ,2017
4. Anil.K Jain, "Fundamentals of Digital image Processing", First Edition, Prentice Hall of India, 1988.
5. Sid Ahmed, "Image Processing", First Edition, McGraw Hill, 1994.

C&I 5202 Nature Inspired Algorithms

Introduction to single and multi-objective optimization, multi agent artificial life worlds, particle Swarm optimization, ant colony optimization, evolutionary computation, genetic algorithms, simulated annealing, evolution strategies, bacterial foraging algorithm, evolution and adaptation of intelligent agents. Applications of nature inspired algorithms in control and optimization. Recent trends in Nature Inspired algorithms.

Suggested Readings:

1. L de Castro, "Fundamentals of Natural Computing", First Edition, CRC Press. Chapman & Hall, 2006ISBN1-58488-643-92, 2006.
2. A. Eiben & J Smith, Introduction to Evolutionary Computing, Springer, 2015.

C&I 5204 Adaptive Signal Processing

Introduction to adaptive signal and array processing, review of estimation theory, minimum mean squared error (MMSE) estimation, linear MMSE estimation. Stochastic gradient algorithms, least mean squares (LMS) algorithm, mean-square performance, transient performance. Least squares algorithms, recursive least squares (RLS) algorithm, Kalman filtering and RLS algorithm

Suggested Readings:

1. H. Sayed, Adaptive Filters, John Wiley & Sons, NJ, ISBN 978-0-470-25388-5, 2008.
2. S. Haykin, Adaptive Filter Theory, Fourth Edition, Pearson Education LPE, 2007.
3. Alexander D. Poularikas, Zayed M. Ramadan, Adaptive filtering primer with MATLAB, CRC Press, 2006.
4. B. Widrow and S.D. Stearns, Adaptive Signal Processing, Prentice Hall, Englewood Cliffs, NJ, 1985.

C&I 5206 Machine Learning

Introduction to learning: Supervised and unsupervised, generative and discriminative models, classification and regression problems; feature selection, dimenstionality reduction using PCA; bayesian classification, discriminative classifiers: perceptrons, multilayer perceptron, RBF networks, decision trees, support vector machines; unsupervised learning: EM algoithm; K-means clustering, DBSCAN, hieararchical Agglomerative Clustering, Density estimation in learning Mean-shift clustering; Classification performance analysis; Ensemble methods: Ensemble strategies, boosting and bagging; Sequence Models: Hidden Markov Models, Probabilistics Suffix Trees; Applications and Case studies.

Suggested Readings:

1. E. Appaydin, Introduction to Machine Learning, 3rd Edition, Prentice Hall (India) 2015.
2. R. O. Duda, P.E. Hart and D.G. Stork, Pattern Classification, 2nd Edn., Wiley India, 2007.
3. C. M. Bishop. "Pattern Recognition and Machine Learning". (Information science and statistics), Springer, 2006.
4. S. O. Haykin, Neutral Networks and Learning Machines, 3rd Edition, Pearson Eductation (India), 2016.

C&I 5208 Special Topics in Control Systems

Review of stochastic processes and identification. Linear quadrature regulator (LQR), Model based control, direct synthesis control, internal model control, generic model control, model reference adaptive control, model reduction techniques.

Suggested Readings:

Semester III

C&I6401 SCADA & Energy Management

Concept of Supervisory control & Data Acquisition System, Component and types of SCADA systems, CT, PT, Voltage to current, current to voltage converters, RTUs etc. Supervisory and control functions, man-machine communication, operator console, VDU display and its use, operator dialogues, mimic diagram functions, printing facilities etc. SCADA system structures, system classes, system interactions, performance criteria, software and hardware considerations, data bases, reliability and simulations, technical realizations, local system, communication system, central system, control system supervision & system maintenance. Application functions-real time network modeling, security management, production control and training simulators.

Introduction to communication systems, Hotline, PLCC, Mobile, Satellite, Microwave & Optical fiber communications. Transputerised SCADA system, SCADA on embedded FPGA.

Suggested Readings:

1. Krishana Kant, "Computer-based Industrial Control", Second Edition, PHI Publication, 2011.
2. Bela G. Liptak, "Process Control", Fourth Edition, CRC Publication, 2005.
3. Madiseth & Williams, "Digital Signal Processing", CRC Press, IEEE Press.
4. Thomas E. Kissel, "Industrial Electronics", First Edition Pearson Publication, 1996.

C&I 6403 Applications of Control in Power Electronic Systems

Overview of power electronic devices and their characteristics, Emerging Devices and Circuits, MOS controlled thyristors, Integrated Gate commutated Thyristors (IGCT), Power Integrated Circuits (PIC's) and smart power control chips. Power Electronics Converters AC to DC converters, DC to AC converters, DC to DC converters, AC to AC converters, cyclo converters topology and structure of power electronics converters, converter protection and future converter applications. Pulse Width Modulation for Power Electronics Converters, PWM methods, voltage control PWM, SPWM, selected harmonic elimination, Minimum ripple current, Delta modulation, current control PWM, space vector method, performance criterion, open loop and closed loop PWM schemes etc. Feedback Control for converters, comparator based control of rectifiers systems, and P & PI control applications. Applications to Motor drive, UPS, Static Var Compensators (STATCOM), Active Power filter.

Suggested Readings:

1. E. Acha, VG Agelidis, O Anaya – Lara, TJE Miller, "Power Electronic Control in Electrical system", First Edition, Newnes, 2002.
2. S.R Doradla, G.K Dubey, "Thyristorised Power Controllers", First Edition, Prentice hall, 1986.
3. Undeland, Mohan, "Power Electronics converter application and design", Third Edition, John Wiley and sons, 2007.
4. JMD Murphy, "Thyristor control of AC Motors", First Edition, Pergamon Press, Oxford, 1973.
5. M.H. Rashid, "Power electronics and AC drives", Third Edition, PHI, 2004.

C&I6405 Microcontroller & Embedded Systems

Organization of a microprocessor, register organization, C.P.U. Description of timing and control units, interfacing memory & I/O devices Synchronous & Asynchronous data transfer, Interrupt, Polling, DMA, Introduction to Pentium and Pro-Pentium microprocessor. Basic organization of 8051, 8097, MC68HC11, PIC16CXX, SLK-51 microcontrollers, instruction set- timing diagram, address modes, simple program and applications. Embedded system and their components, categories of embedded systems. Stand alone, Real time Networked and Mobile etc., Requirements of embedded systems. Reliability, cost effectiveness, low power consumption, efficient use of processing power, efficient use of memory, approximate execution time, challenges and issues in embedded software development. Co design operating system, efficient I/O testing and debugging. Hardware Architecture for embedded systems. Embedded Applications.

Suggested Reading:

1. D.V. Hall, "Microprocessors-Principles & Applications", Second Edition, TMH, 2005.
2. Ramesh Gaonkar, "Microprocessor Architecture, Programming and Applications with 8085", Sixth Edition, Penram Publications, 2013.
3. John B. Peatman, "Design with PIC Microcontrollers", First Edition, Pearson Education, Asia, 1987.
4. Michael Kheir, "The M68HC11 Microcontrollers", Application in control, Instrumentation and communication", First Edition, Prentice Hall, New Jersey, 1996.
5. John B. Peatman, "Design with Microcontrollers", First Edition, McGraw Hill, 1988.

C&I 6407 Digital Instrumentation

Signals from process instrumentation, signal conditioning for the control computer, signal transmission, time division multiplexing, signal termination. Digital control loop, analysis of block diagrams, stability systems with dead time. The computer control system. CPU, relationship of word length to performance, peripheral devices, optimization/control of a distillation column, control algorithms, Dahlin's method, and standard algorithms. PC based industrial process measurements like flow, temperature, pressure and level – PC based instruments development system. Concept of Supervisory control & Data Acquisition System, Component and types of SCADA systems, CT, PT, Voltage to current, current to voltage converters, RTUs etc.

Suggested Readings:

1. Kevin M. Daugherty, "Analog – to – Digital conversion – A Practical Approach", First Edition, McGraw Hill International Editions, 1993.
2. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice – Hall of India Pvt. Ltd, 2003.
3. Krishana Kant, "Computer-based Industrial Control", Second Edition, PHI Publication, 2011.
4. H.S. Kalsi, "Electronic Instrumentation", Third Edition, Technical Education Series (TES)/TMH, 2017.
5. Buchanan, "Computer busses: Design and Applications", First Edition, Butterworth-Heinemann, 2000.

C&I 6301 Robot Dynamics & Control

Introduction, Geometric configuration of robots. Robot arm Kinematics: Direct and inverse kinematics – Rotation Matrices – Composite rotation matrices – Euler angle representation – Homogenous transformation – Denavit Hattenberg representation and various arm configuration. Robot Arm Dynamics, Lagrange – Euler formulation, joint velocities – Kinetic energy – Potential energy and motion equations – Generalised D'Alembert equations of motion. Planning of Manipulator Trajectories, General consideration on trajectory planning joint interpolation & Cartesian path trajectories. Control of Robot Manipulators, PID control computed torque technique – Near minimum time control – variable structure control – Non-linear decoupled feedback control – Resolved motion control and adaptive control.

Suggested Readings:

1. Fu, K.S. Gonazlez, R.C. and Lee, C.S.G., "Robotics (Control, Sensing, Vision and Intelligence)", First Edition, McGraw-Hill, 1987.
2. Wesley, E. Snyder, "Industrial Robots: Computer interfacing and Control", First Edition, PHI, 1985.
3. Asada and Slotine, "Robot Analysis and Control", First Edition, John Wiley and Son, 1986.
4. Philippe Coiffet, "Robot Technology" Vol. II (Modelling and Control), First Edition, Prentice Hall INC, 1983.
5. Saeed B. Niku, "Introduction to Robotics, Analysis, systems and Applications", First Edition, Pearson Education, 2001.
6. Groover M.P. Mitchell Wesis., "Industrial Robotics Technology Programming and Applications", First Edition, Tata McGraw-Hill, 1986.

C&I 6303 Stochastic Control

Random variables, Stochastic Processes and their properties, Probability density functions. Moments Ergodic hypothesis and ensemble averages, correlation functions and power spectral density functions. M.S.E. minimization, Filtering and prediction problems, Wiener-Hopf equation, Frequency domain system design.

Suggested Readings:

1. A.P. Sage, "Optimal System Control", Second Edition, Prentice Hall, 1977.
2. J.H. Laning and R.H. Batin, "Random Signals in Automatic Controls", Tata McGraw Hill
3. G.C.Newton, L.A. Gonld, J.F. Kaiser, "Analytical design of feedback control systems", First Edition, John Wiley, 1957
4. J.S. Meditch, "Stochastic Optimal Linear Estimation & Control", First Edition, Tata McGraw Hill, 1969.

C&I 6305 Adaptive Control

Single input single output continuous time and discrete time affine systems, multi-input multi-output systems, back stepping control, discrete time non-affine systems, and strict feedback form. Feedback linearization, State feedback linearizable systems, model identification using neural networks. Robust back stepping controller design. Indirect adaptive control using neural networks, direct adaptive control using neural networks. Adaptive control using TSFS.

Suggested Readings:

1. D.K Pratihar, "Soft Computing Techniques", First Edition, Alpha Publications, 2013.
2. J.S.R Jang, C.T. Sun, E. Mizutani, "Neuro-fuzzy and soft Computing", First Edition, Pearson Education, 1997.
3. Behera L., Kar I., "Intelligent Systems and Control", Oxford Higher Education, 2009.
4. Omidvar Omid and Elliott David L., "Neural Systems for control", First Edition, Academic Press Limited, 1997.
5. Lin C.T. and Lee C.S.G. , "Neural Fuzzy Systems", First Edition, Prentice Hall PTR, 1996.

C&I 6307 Instrumentation Transducers

Transducers and their characteristics, Definition of terminologies Generalized performance characteristics range resolution linearity overload factor accuracy precision static and dynamic rise time fall time settling time slew rate frequency response bandwidth modelling Classification ingress protection vibration isolation passive active. Resistive Transducers, Resistance potentiometer noise resolution signal conditioning strain gauges associated electrical circuitry temperature compensation load cells torque and pressure measurement using strain gauges resistive temperature device (RTD) three-lead arrangement thermistors linearization - hot-wire anemometers time constant improvement measurement of direction of flow peizo resistive transducers. Inductive Transducers, signal conditioning circuits choice of components linear variable differential transducer (LVDT) lead and lag compensation. Parasitic effects solutions, miscellaneous transducers, Peizo electric signal conditioning thermo couples' theory mass-spring accelerometer force-balance. Applications of transducers, Measurement of displacement (linear and angular) velocity acceleration force torque pressure flow-temperature.

Suggested Readings :

1. Neubert, H. K. "Instrument Transducers-An introduction to their performance and design", Second edition, Oxford University press, 2003.
2. Doeblin, E. O. "Measurement Systems Application and Design", Fifth Edition, McGraw - Hill Publications, 2004.

C&I 6309 Advanced Control System Design

Review of sample and hold devices, Reconstruction, Z transform – Properties – Pulse transfer function and state variable approach – Review of controllability and observability. Computer Based Control, Selection of processors – Mechanization of control algorithms – PID control laws predictor merits and demerits – Application to temperature control and data communication for control. Optimal Controller Design, Statement of optimal control problem- Solution using variational approach-Ricatti equation- -Infinite time problems, introduction to robust control. Slide mode control, H ∞ and H-2 control, model reference control and adaptive control.

Suggested Readings:

1. Gopal. M., "Digital control Engineering", Wiley Eastern Ltd.
2. G.F. Franklin, J.David Powell, Michael Workman, "Digital control of Dynamic Systems", 3rd Edition, Addison Wesley.
3. Paul Katz, "Digital control using Microprocessors", Prentice Hall.
4. Forsytheand. W. Goodall. R.N., "Digital Control", McMillan.
5. Chesmond, Wilson, Lepla, "Advanced Control System Technology", Viva – low price edition.

C&I 6201 Special Topics in Instrumentation

Extreme Environments and Their Effects, Extreme Environments, Radiation Effects on Electronics, Temperature effects. Instrumentation for Extreme Environment Systems, Basic Instruments, Analyzing and modeling EE on Instruments. Mitigation Strategies, Robust material and device technologies, Packaging, Hardening-by Process, Hardening by Design

Suggested Readings:

1. NSREC Archive of Short Course Notebooks, 1980-2006
2. https://ieee-npss.org/distinguished-lecturers/

C&I 6203 Special Topics in Signal Processing

Compressed Sensing and Sparse Recovery, PCA and Low-Rank Matrix Estimation, Low-Rank Matrix Recovery/Phase Retrieval, Low-Rank Matrix Completion/Robust PCA, First-Order Algorithms for Nuclear Norm Minimization

Suggested Readings:

1. Trevor Hastie, Robert Tibshirani, and Martin Wainwright, "Statistical learning with sparsity: the Lasso and generalizations", Chapman and Hall/CRC, 2015.
2. Simon Foucart, and Holger Rauhu, "A mathematical introduction to compressive sensing", Springer, 2013

3. Emmanuel Candes, "Mathematics of sparsity", International Congress of Mathematicians, 2014.

4. Roman Vershynin, "Introduction to the non-asymptotic analysis of random matrices", Arxiv, 2017.

5. Stephen Boyd, and Lieven Vandenberghe, "Convex optimization", Cambridge University Press, 2004.

6. Terence Tao, "Topics in random matrix theory", American MathematicalSociety, 2012.

C&I 6205 Digital Communication

Review of random variables and random process, signal space concepts, Common modulated signals and their power spectral densities, Optimum receivers for Gaussian channels, Coherent and non-coherent receivers and their performance (evaluating BER performance through software tools), Basics of Information theory, source and channel coding, capacity of channels, band-limited channels and ISI, multicarrier and spread spectrum signalling, multiple access techniques

Suggested reading:

1. John G Proakis and Salehi, Digital Communication, Fifth Edition, McGraw-Hill, 2007.

2. 2. John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communications, Springer, third edition, 2004

C&I 6207 Pattern Recognition

Introduction to pattern recognition and its applications, Bayesian decision theory. Bayesian estimation: Gaussian distribution, ML estimation, EM algorithm Feature selection and extraction, Linear Discriminant Functions, Nonparametric Pattern Recognition, Algorithm-independent Learning, Comparing classifiers, Learning with Multiple Algorithms, Syntactic Pattern Recognition

Suggested Readings:

1. R.O.Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2001.

2. K. Fukunaga , "Statistical pattern Recognition", Academic Press, 2000.

3. S.Theodoridis and K.Koutroumbas, "Pattern Recognition", Academic Press, 2009

C&I 6209 Artificial Intelligence

Foundation for AI: Applications areas, AI Basics (Divide and conquer, Branch and Bound, Gradient Descent), NN Basics (Preceptron and MLP, FEN, Back propagation). COnvolution Neural Networks: Image Classification, text classification, Image Classification and hyper-parameter tuning, emerging NN architectures, Recurrent Neural Networks: Building recurrent NN, long short-term memory, Time series forecasting. Deep Learning: Auto-encoders and unsupervised learning, stacked auto-encoders and semi-supervised learning, regularization-droput and normalisation.

Suggested Readings:

1. S. O. Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Eduction (India), 2016.

2. I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2017.

Semester IV

C&I652 Research Project

C&I602 Major Project II

DEPARTMENT OF ELECTRICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Power System)

Programme Specific Outcomes

1. To be able to apply the knowledge of Electrical Engineering fundamentals to the solution of complex problems in advanced power systems.
2. To be able to design system components of processes that meet the specified needs with appropriate considerations for the public health, safety and culture, societal and environmental considerations.
3. To be able to crate, select and apply modern techniques resources and modern engineering and IT tools including simulation and modeling of modern power systems
4. To be able to understand, analyze and demonstrate the principles of engineering and apply these ones to carry out the advanced research projects.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN POWER SYSTEM (PSY)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	PSY501	Advanced Power System Analysis	Core	4	3	0	2	15	25	20	40	-	17
	2	PSY503	Advanced Power Electronics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	PSY5401/5403/.....	Elective 1	Elective	4	3	0	2	15	25	20	40	-	
	4	PSY5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	PSY5201/5203/..... /UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	PSY502	Advanced Power System Protection	Core	4	3	0	2	15	25	20	40	-	17
	2	PSY504	Power System Operation and Control	Core	4	3	0	2	15	25	20	40	-	
Group D	3	PSY5402/5404/.....	Elective 4	Elective	4	3	0	2	15	25	20	40	-	
	4	PSY5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	PSY5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
		Track 1												
Group E	1	PSY651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
		Track 2												
	1	PSY601	Major Project I	Core	3						40	60		12
	2	PSY6401/6403/.....	Elective 7	Elective	4	3	0	2	15	25	20	40	-	
	3	PSY6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	PSY6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
		Track 1												
Group F	1	PSY652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
		Track 2												
	1	PSY602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	PSY5401	Power System Dynamics and Stability	Elective	4	3	0	2	15	25	20	40	-
	2	PSY5403	Advanced Control Systems		4	3	0	2	15	25	20	40	-
	3	PSY5405	Modelling of Electrical Machines		4	3	0	2	15	25	20	40	-
	4	PSY5407	Soft Computing Techniques		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	PSY5301	Power System Instrumentation	Elective	3	3	0	0	20	-	30	50	-
	2	PSY5303	Flexible AC Transmission Systems		3	3	0	0	20	-	30	50	-
	3	PSY5305	Optimization Techniques for Power Systems		3	3	0	0	20	-	30	50	-
	4	PSY5307	Applied Mathematics		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
	1	PSY5201	SEMINAR		2	2	0	0	100	-	100	-	-
Elective 3	2	PSY5203	Nuclear Energy and Power	Elective	2	2	0	0	20	-	30	50	-
	3	PSY5205	Forecasting Techniques in Power Systems		2	2	0	0	20	-	30	50	-
	4	PSY5207	Switched Mode Power Supplies		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	PSY5402	Renewable Energy Systems	Elective	4	3	0	2	15	25	20	40	-
	2	PSY5404	High Voltage Engineering		4	3	0	2	15	25	20	40	-
	3	PSY5406	Power Quality		4	3	0	2	15	25	20	40	-
	4	PSY5408	Advanced Digital Signal Processing		4	3	0	2	15	25	20	40	-
	5	PSY5410	High Voltage DC Transmission		4	3	0	2	15	25	20	40	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	PSY5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	PSY5304	Intelligent Control Techniques		3	3	0	0	20	-	30	50	-
	3	PSY5306	Analog Filter Design		3	3	0	0	20	-	30	50	-
	4	PSY5308	Dynamics of Synchronous Machines		3	3	0	0	20	-	30	50	-
	5	PSY5310	Smart Grid		3	3	0	0	20		30	50	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	PSY5202	Restructured Power Systems	Elective	2	2	0	0	20	-	30	50	-
	2	PSY5204	Power System Planning		2	2	0	0	20	-	30	50	-
	3	PSY5206	Machine learning		2	2	0	0	20	-	30	50	-
	4	PSY5208	PMU and Advanced Metering		2	2	0	0	20	-	30	50	-
		PSY5210	EHV AC Power Transmission		2	2	0	0	20	-	30	50	
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	PSY6401	SCADA & Energy Management	Elective	4	3	0	2	15	25	20	40	-
	2	PSY6403	Computer Aided Power System Analysis		4	3	0	2	15	25	20	40	-
	3	PSY6405	Microcontroller & Embedded Systems		4	3	0	2	15	25	20	40	-
	4	PSY6407	Advanced Electric Drives		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	PSY6301	Power System Reliability	Elective	3	3	0	0	20	-	30	50	-
	2	PSY 6303	Transients in Power Systems		3	3	0	0	20	-	30	50	-
	3	PSY6305	Advanced Distribution Systems		3	3	0	0	20	-	30	50	-
	4	PSY6307	Grid and Sub-Station Planning and Technologies		3	3	0	0	20	-	30	50	-
	5	PSY6309	Modern Electric Traction System		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	PSY6201	Energy Auditing and Conservation	Elective	2	2	0	0	20	-	30	50	-
	2	PSY6203	Electricity Market and Regulations		2	2	0	0	20	-	30	50	-
	3	PSY6205	Digital Communication		2	2	0	0	20	-	30	50	-
	4	PSY6207	Energy, Ecology and Environment		2	2	0	0	20	-	30	50	-
	5	PSY6209	Artificial Intelligence		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

PSY501 Advanced Power System Analysis

Introduction and design considerations of EHV AC systems. Analysis of long transmission lines. Modelling of power system components. Formation of power network matrices. Power Flow studies. N-R method, decoupled and fast decoupled methods. Programming considerations for large systems – sparse matrix techniques. Economic Load Dispatch, Optimal Power Flow, Fault Studies - Symmetrical and unsymmetrical faults using matrix methods. Stability Studies – Transient and dynamic stability analysis of single machine connected to infinite bus and multi-machine systems.

Suggested Reading:

1. Stagg G. & El Abiad, A.H., Computer Methods in Power System Analysis, McGraw Hill.
2. Anderson P.M., Analysis of Faulted Power Systems, IEEE Press.
3. Arrillaga J., Arnold C.P., Computer Modelling of Electrical Power Systems, John Wiley.
4. Wood & Wollenberg, Power Generation, Operation and Control, John Wiley.
5. Elgerd, O.I., Electric Energy Systems Theory, TMH.

PSY503 Advanced Power Electronics

Solid-State Devices: Review of SCR, driving circuits and protection; Modern semiconductor devices and their operating characteristics; Heat sink design.

Phase Controlled Converters: Effect of load and source impedances, effect of free-wheeling diode; Three-phase, fully controlled and half controlled, twelve-pulse converters; Multi-pulse converters; Dual converters, Improved quality converters, power factor improvement techniques, PWM converter.

DC-DC Converters: Buck, Boost and Buck-Boost, Cuk, Fly-back converters; AC-AC Converters: Three-phase ac regulators, operation with resistive load; Single-phase and three-phase cyclo-converters; Matrix converters, output voltage control techniques, commutation methods.

Inverters: Review of three-phase voltage source inverters, voltage and frequency control; Harmonic reduction techniques, PWM inverters, Space Vector Modulation; Multi-level inverters, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications; Current source inverter, commutation circuits, transient voltage suppressing techniques; DC link resonant converters, operation and control. Simulation Techniques: MATLAB simulation of power electronic converters.

Suggested Reading:

1. Dubey G. K., Doradla S. R., Joshi A. and Sinha R. M. K., "Thyristorised Power Controllers", New Age International Private Limited.
2. Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", 3rdEd., Wiley India.
3. Bose B.K., "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, Standard Publisher Distributors
4. Lander C. W., "Power Electronics", 3rdEd., McGraw-Hill International Book Company
5. Rashid M., "Power Electronics- Circuits, Devices and Applications", 3rdEd., Pearson Education.

PSY5401 Power System Dynamics and Stability

Basis concepts of dynamical systems, Modelling of power system components for stability studies, generator, excitation systems, prime mover controller and associated systems, induction machines and composite loads, transmission lines. Analysis of single machine and multi machine systems. Small signal stability, low frequency oscillations, damping and synchronizing torque analysis, eigenvalue analysis. Power System Stabilizers. SSR and torsional oscillations-analysis and countermeasures.

Suggested Reading:

1. Power System Stability by Kimbark Vol. I&II, III – 1968, Dover Publication Inc, New York 1968.
2. Power System control and stability, P.M. Anderson & A.A. Fouad, Galgotia Publications New Delhi – 110060, 1981, 1st edition.
3. Power System Dynamics Stability and Control by K.R.Padiyar, Second edition B.S.Publications 2002.
4. Power System Analysis by John J.Graniger William D.Stevenson. JR. – Tata McGraw Hill Publications.
5. Kundur, P., "Power System Control and Stability", McGraw Hill.
6. Pai, M.A., and Sauer. P., "Power System Dynamics & Stability", Prentice Hall.

PSY5403 Advanced Control Systems

Modeling of dynamical systems in continuous time state space and discrete time state space model, Solution of continuous time state equation, Solution of discrete time state equation. General concept of Controllability and Observability, Controllability test for continuous time and discrete time system, Observability test for continuous time and discrete time system, Stabilizabilty and Detectability definition and tests, loss of Controllability and Observability due to sampling, Controllable and Observable canonical forms. Nonlinear Models, Equilibrium points, Linearization of Nonlinear models, Separable Nonlinearities, Describing function analysis, Phase plane analysis of nonlinear systems, Bang-Bang control system, feedback linearization. Stability concept, stability definition in the sense of Lyapunov, Lyapunov stability theorem, Lyapunov instability theorem, direct method of Lyapunov for continuous time and discrete time systems, Lyapunov function for nonlinear systems. Pole placement technique, Ackerman's approach and Linear quadratic regulator for continuous time and discrete time systems, sliding mode control, H-infinity control, full order and reduced order observer design.

Suggested Reading:

1. J.P. Hespanha, " Linear Systems Theory", Second Edition, Princeton University Press, 2018.
2. Hostetter G. H., Savant, and Stefani, Design of Feedback Control Systems, Oxford University Press ,2001.
3. Kailath Thomas, Linear Systems, Prentice Hall ,1996.
4. Khalil, H., Nonlinear Systems, 3nd Ed., Macmillan, 2002
5. Slotine, J.J., and Li. W.P., Applied Nonlinear Control, Prentice-Hall, 1991.
6. Vidyasagar M., Nonlinear Systems Analysis, Prentice Hall, 2nd Edition ,1992

PSY5405 Modelling of Electrical Machines

Generalized transformations, Physical model, Different reference frames, Primitive machine, dynamic variable, Formulation of dynamic equations of a generalized machine in arbitrary reference frame Analysis of induction machines, Space vector, induction motor modeling in arbitrary reference frame and in field oriented frame, Performance analysis Analysis of synchronous machine, Modeling, Operational impedances, Time constants, torque expression, Asynchronous damping, Steady state and transient performance, Phasor diagram and power angle characteristics, Symmetrical and asymmetrical short circuit analysis, Measurement of reactances and time constants

Suggested Reading:

1. Concordia, Charles, "Synchronous Machines- Theory and Performance", Wiley, New York. 1989
2. Kimbark E.W., Power System Stability: Synchronous Machines", Vol.3, Cover Publication, New York. 1976.
3. Adkins B., Harley R.G., "The Generalized Theory of Alternating Current Machines", Chapman & Hall, London. 1979
4. Leonard W., "Control of Electrical Drives", 3rd Edition. Springer 2002 Press, New York.
5. Murphy J.M.D., Turnbull F.G., "Power Electronics Control of AC Motors", Pergamon Press, New York. 1988.

PSY5407 Soft Computing Techniques

Introduction to crisp set and fuzzy sets, Operations on fuzzy sets. Fuzzy relations, fuzzy measures, fuzzy rules, membership functions, rule base, fuzzy models. Introduction to neural network, Learning schemes, supervised, unsupervised learning, incremental and batch training, backpropagation algorithm, the perceptron neural network, multilayer perceptron, radial basis function networks, self-organizing map, recurrent neural network, Elman networks, Jordan networks etc., Neuro-dynamics, applications of neural network. Basic concept of Genetic algorithm and detailed algorithmic steps. Solution of typical control problems using genetic algorithm. Concept of some other search techniques like tabu search and ant-colony search, biography based optimization techniques for solving optimization problems.

Suggested Readings:

1. Jacek M. Zuarda, "Introduction to Artificial Neural Systems, "Jaico Publishing House, 1997.
2. G.J. Klir & T.A. Folger, "Fuzzy sets, uncertainty and information", First Edition, Prentice-Hall of India, 1988.
3. H.J. Zimmerman, "Fuzzy set theory-and its Applications", Fourth Edition, Kluwer Academic Publishers, 2001.
4. Driankov, Hellendron, "Introduction to Fuzzy Control", Second Edition, Narosa Publishers, 1996.

PSY5301 Power System Instrumentation

Measurement of Electrical Quantities: Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants; Energy meters and multipart tariff meters Voltage and Current Transformers: Voltage transformers for measurement and protection, errors, transient performance; capacitive voltage transformers and their transient behavior; Current transformers for measurement and protection, composite errors, transient response. Hydro Electric Power-Plant

Instrumentation: Measurement of flow, level, pressure, temperature, hydraulic head and mechanical vibrations; Temperature scanners; Alarm annunciators. Thermal Power-Plant Instrumentation: Measurement of gas flow; Gas and feed-water analysis; Flame monitoring; Steam turbine instrumentation Nuclear Power-Plant Instrumentation: Reactor safety, neutron flux measurement; Reactor power level and coolant measurements Proactive Relays: Organization of protective relay; Single input, two-input and multi-input relays; Electromagnetic, electronic and digital relays.

Suggested reading:

1. Modern Power Station Practice, Volume F: Control and Instrumentation", British Electricity International, Peragmon Press,1990.
2. Elliott T. C., "Standard Hand Book of Power Plant Engineering", McGraw-Hill International Book Company,1989
3. Van A. R. and Warrington C., "Protective Relays- Their Theory and Practice", Vol. 1, Chapman and Hall Ltd,1968
4. Rao T. S. M., "Power System Protection – Static Relays with Microprocessor Applications", 2ndEd., Tata McGraw-Hill Publishing Company Limited, 2008

PSY5303 Flexible AC Transmission Systems

Introduction, principles of reactive power control and transmission line compensation, series and shunt reactive power compensation, concept of Flexible AC Transmission systems (FACTS), Static Var Compensator (SVC), thyristor controlled reactor, thyristor switched capacitor, thyristor controlled series capacitor, static synchronous compensator, static synchronous series compensator, thyristor controlled phase angle regulator and unified power flow controller. Modeling and analysis of SVC, STATCOM, TCSC, SSSC, UPFC and IPFC, use of FACTS controllers in system control and protection. Harmonic and filters, simulation and study of FACTS Controllers under dynamic conditions.

Suggested reading:

1. Miller, T.J.E., "Reactive Power Control in Electric Systems", John Wiley.
2. Hingorani, N.G., and Gyugyi, L., "Understanding FACTS", IEEE Press.
3. E. Acha, V.G. Agelidis, "Power Electronic control in Electrical Systems", Newnes, Butterworth, Elsevier.
4. R.M. MATHUR, R.K. VARMA, " Thyristor based FACTS controller for Eletctrical Transmission systems, John Wiley.

PSY5305 Optimization Techniques for Power Systems

Introduction to power system optimization problems and linkages. Optimization basics and solution techniques for convex and nonconvex optimization problems. Static and dynamic optimization techniques. Basic Optimal power flow. Preventive and corrective security constrained optimal power flow, Unit commitment, hydrothermal scheduling, generation, transmission and reactive expansion planning. Optimization with uncertain data, Fuzzy and probabilistic techniques. Generation, transmission and reactive resources planning. Renewable generation integration optimization. Effect of markets and renewable generation in resources planning

Suggested reading:

1. Power generation operation and control, Wood and Woolenberg, WSE
2. Optimization on Power system Operation by Jizhong Zhu Wiley-IEEE Press.
3. S. S. Rao, "Optimization – Theory and Applications", Wiley Eastern Limited, Second Edition, 1984.
4. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples", Prentice Hall India
5. D.P. Kothari, "Power System Optimization", TMH

PSY5307 Applied Mathematics

Review of sets, relations and mappings, Boolean algebra, and laws of probability. Bayes theorem. Random variable, Expectation, Moments and covariance. Probability as a set function. Second order random functions, Gaussian random functions. Poissori process, Markov Chain, Auto/cross correlation . Linear vector spaces over a field subspace, bases, dimension and linear transformations. Quadratic forms. Eigen,values using QR transformations, generalized Eigen vectors, canonical forms, singular value decomposition and applications, pseudo inverse. Solution of non linear differential equations. Finite differences and finite element. Calculus of variations. concept of variation and its properties, finite differences and finite elements methods. Euler's equation, functional dependant on first and higher order derivatives, functional dependants on functions of several independent variables, variation problems with moving boundaries, isoperimetric problems, direct method, Ritz and Kantorovich methods

Suggested reading:

1. Bronson, R., Matrix Operations, Schaum's outline series, McGraw Hill, New York.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Taha, H.A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi.
4. Ochi, M.K., Applied Probability and Stochastic Processes, John Wiley and sons.

PSY5201 SEMINAR

PSY5203 Nuclear Energy and Power

Introduction to Nuclear Physics, Basics atomic structure, mass energy equivalence, Interaction of radiation with matter, nuclear reactions fission and fusion, Energy released in reactions. Nuclear Power reactors: - Comparison of Nuclear and Fossil fuel. Heat generation and heat removal from the reactor, steam-cycles. Types of Thermal Reactors: Boiling Water, Pressurized water reactors, CANDU, High temperature gas cooled reactor, superheat in water reactor Fast Breeder Reactors. Nuclear power plant layout, Radiation Shielding, Nuclear power station operation, instrumentation and control: Irradiation effects, effects of temperature. Fuel cycles, instability, reactor control, start up and shunt down, reactor safety, reactor power level measurement, safety circuits.

Suggested reading:

1. Ken Kok, "Nuclear Engineering Hand book", Taylor and Francis.
2. N.Sharma, B.Banerjee "Nuclear power in India", Rupa (1 July 2008)
3. P.B. Myerscough, "Modern power Station Practice"
4. Ram, K.S. "Basic Nuclear Engineering", New Age International Pvt. Limited.

PSY5205 Forecasting Techniques in Power Systems

Principles of forecasting load, wind and price. Statistical and non-statistical based approaches. AI application for forecasting. Fundamentals of deregulated power market, Market time lines Forecast based decision time frames Principles of forecasting, Taxonomy of forecasting techniques, univariate/ multivariate forecasting, forecasting performance measurement. Statistical forecasting Overview of regression, time series techniques AR, MA, ARMA, ARMAX, ARIMA.

Artificial Intelligence Techniques: fundamentals, mathematical modeling Neural Networks Fuzzy Neural Networks Support Vector Machines Hybrid Techniques Load Forecasting: Key issues and challenges. Data and feature selection, analysis and preprocessing, Price forecasting Key issues and challenges, price spikes and volatility analysis, Data selection, analysis and preprocessing, Feature selection, Modeling Model application and validation, Wind speed/power forecasting, ramp forecasting, Key issues and challenges, Uncertainty quantification of forecasts, Confidence/ Prediction Intervals, Future Scope and new challenges in emerging smart grid environment.

Suggested reading:

1. Mohammed Shahidehpour, Hatim Yamin, Zui Li, Market Operations in in Electric Power System: forecasting, scheduling and risk mangement, John Wiley & Sons Ltd, 2002.
2. Rafal Weron, Modelling and Forecasting Electricity Loads and Prices: A statistical approach, John Wiley & Sons Ltd, 2006.
3. G.P. Box and G.M. Jenkins, Time Series Analysis: Forecasting and Control, Holden-Day Inc.
4. S. Makridakis, S.C. Wheelwright, R.J. Hyndman, Forecasting Methods and Applications, Wiley, 1998.
5. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer, 2013.

PSY5207 Switched Mode Power Supplies

Introduction: Overview of linear voltage regulators, shunt and series regulators. Switching Concepts: Ideal switch, practical switch, switching functions. Switching Circuits: Introduction of switching circuits, harmonic concepts, power computations. Non-Isolated Switch-Mode DC-DC Converters: Buck, Boost, Buck-Boost converters. Isolated Switch-Mode DC-DC Converters: Introduction and types of switch mode dc-dc converters. Soft Switched DC-DC Converters: Series and Parallel resonant circuits, ZCS and ZVS switching topologies. Simulation of Switching Converters. Switching Converter Design: Choke and transformer design; driver circuits, snubber circuits; EMI suppression, Input rectifiers with unity input power factor; Reliability, few case Studies.

Suggested reading:

1. Rashid M. H., "Power Electronics Circuits Devices and Applications", 3rd ed Pearson Education 2008
2. Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics-Converters, Applications and Design", 3rd ed Wiley India 2008
3. Whittington H.W., Aflynn B.W. and Macpherson D.E., "Switch Mode Power Supplies – Design and Construction", John Wiley and Songs. 1997
4. Hart Daniel W., "Introduction to Power Electronics", Prentice Hall International Edition. 1996
5. Luo Fang Lin and Ye Hong, "Advanced DC/DC Converters", CRC Press. 2003

SEMESTER II

PSY502 Advanced Power System Protection

Review of relay characteristics and operating equations with respect to static comparators. CTs, PTs and mixing transformers, effect of CT saturation on relay operation. Basic construction of static relays, input output devices, D.C. supplies and associated elements; time delay circuits. Static comparators: Different types of two input amplitude and phase comparators; theory and operation, effect of offset and remedy. Introduction of multi input comparators and characteristics. Transient over voltages and their suppression; Different type of relays: static, digital and computer aided relaying. Bus bar arrangements; High current bus bars and design consideration. Review of arc formation, properties and characteristics; interruption of current in circuit breakers; high resistance and low resistance theories of interruption; Effect on circuit breaker performance under different conditions in power system operation; Circuit breaker ratings. Study and operation of air blast, SF6, vacuum and D.C. circuit breakers. Selection and design considerations, Circuit breaker testing methods as per standard.

Suggested Reading:

1. R. van C. Warrington, "Protective Relays Their Theories and Practice". Volume II, Third Edition, John Wiley & Sons, Inc, New Yark.
2. Ravindranath and M. Chander,"Power System Protection and Switchgear", First Edition, New Age International (P) Limited
3. Ram And D. N. Vishwakarma, "Power System Protection And Switchgear", Ninth Reprint, Tata McGraw-Hill Publishing Company
4. R. T. Lythall, "The J&P Switchgear Book". Seventh Edition, Newnes-Butterworth.
5. Stan Stewart, "Distribution Switchgear", The Institution of Electrical Engineers, London.
6. Power System Relaying, Stanley H Horowitz and A G Phadke, Willey, 2014.

PSY504 Power system operation and control

General characteristics of modern power systems, evolution, structure, power system control, operating states of a power system and control strategies, economic load dispatch, price based unit commitment problem. Concept of reactive power, reactive power flow analysis, active power and frequency control, real power balance and its effect on system frequency; Static VAR systems, types of SVC, fundamental frequency performance of SVC, application of SVC. Automatic generation control

(AGC), generation control loops, load frequency control, AGC with economic dispatch performance measures, large signal, small signal, control and protective functions, ac and dc regulators, design of robust controllers in power systems. Division of power system into control areas, load-frequency control of single area and two area system - optimum control criterion, two area and multi-areas power system with and without integral control, SCADA systems and its applications in power networks, supervisory control, supervisory master stations, remote terminal units, communication links.

Suggested Reading:

1. Elgerd O.I, "Electric Energy System Theory – an Introduction", Tata McGraw Hill, New Delhi.
2. Kundur. P., "Power System Stability and Control", EPRI Publications, California
3. Allen J. Wood and Bruce. F. Wollenberg, "Power Generation Operation and Control', John Wiley & sons, New York.
4. Mahalanabis A.K., Kothari. D.P. and Ahson. S.I., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd.
5. Vaibhav Donde, M.A. Pai & Ian A. Hiskens – "Simulation & Optimization in an AGC system after deregulation", IEEE transactions on Power Systems
6. L.K.Kirchmeyer, "Economic Control of Interconnected systems", Wiley
7. R.N. Dhar, "Computer Aided power system operation and analysis", TMH

PSY5402 Renweable Energy Systems

Basics of energy, conventional energy sources, renewable energy sources, global and Indian energy scenario, new technologies (hydrogen energy, fuel cells, bio fuels). Solar Energy: Theory of solar cells, solar cell materials, I-V characteristics of solar cell, PV module, PV array, MPPT, PV systems, Stand alone and grid connected PV systems, storage, PV based water pumping, solar radiation and its measurement, flat plate collectors and their materials, applications and performance, solar thermal power plants, limitations. Wind Energy: site selection, power in the wind, impact of tower height, classification of wind turbine and rotors, wind energy extraction, betz'z limit, wind characteristics, performance and limitations of wind energy conversion systems. Biomass, Small Hydro and geothermal energy. Emerging technologies for power generation: Introduction to tidal energy, wave energy, OTEC, principle of working of various types of fuel cells and their working, performance and limitations, Emergence of hydrogen, cost analysis of hydrogen production, hydrogen storage.

Suggested reading:

1. Duffie and Beckmen, Solar Engineering of Thermal Processes, Wiley Publications, 1991.
2. S. P. Sukhatme, Solar Energy, TMH, India, 2008.
3. John Twiden and Tony Weir, Renewable Energy Resources, BSP Publications, 2006.
4. D. P. Kothari, Rakesh Ranjan, Renewable Energy Sources and Emerging Technologies, PHI, India, 2011.
5. C. S. Solanki, Renewable Energy Technologies, A Practical Guide for Beginners, PHI, India, 2012.
6. G. D. Rai, Non Conventional Energy Resources, Dhanpat Rai, India 2006

PSY5404 High Voltage Engineering

Breakdown in Gases, Breakdown in Uniform field, Townsend's mechanisms, Streamer Theory, Paschen's Law, breakdown in electronegative gases. Breakdown of gases in non-uniform field: effect of space charge, corona for positive and negative polarities. Breakdown phenomena under AC voltage and impulse voltage. Breakdown in Liquids: Classification of liquids, breakdown in pure liquids, breakdown in commercial liquids. Breakdown in Solids: Intrinsic breakdown, electromechanical breakdown, Thermal breakdown, Treeing and tracking, breakdown in Composite Insulators. Generation of high direct voltages: Rectifier circuits, voltage dcubler and multiplier circuits, cascade circuits; Cascaded transformers, series resonant circuits; Characteristics of impulse and switching surge voltage, analysis of single stage impulse generator circuit, multi-stage impulse generators, constructional features of multi-stage impulse generators. Generation of Switching surges. High Voltage Testing of Power System Equipments. Over-voltages in Power Systems and Insulation Co-ordination.

Suggested reading:

1. Naidu, M.S. and Kamaraju, V. , "High Voltage Engineering", TMH
2. Wadhwa, C.L., "High Voltage Engineering", Wiley Eastern
3. Westinghouse Transmission & Distribution Reference Book, IBH
4. Kuffel & Zaengl, "High Voltage Engineering", Pergamon Press.

PSY5406 Power Quality

Classification of Power Quality issues, characterization, Power acceptability curves – Power quality problems: Poor load power factor, Non-linear and unbalanced loads, DC offset, Notching, Disturbance, flicker, transients, voltage fluctuations, sags/swells/unbalance, Power Quality Indices, recommended practices, Influence of Non-Sinusoidal Conditions: Transmission and Distribution, Resonance, Shunt capacitors, Transformers, Inrush currents, Electric Machines, Ground systems. Voltage, Current, Power and Energy measurements, power factor measurement, Analysis in the periodic steady state, Time domain method, Frequency domain methods, IRPT, SRF Theory, instantaneous symmetrical components, Analysis of unbalanced systems, Analysis and reduction of voltage sag, Harmonics & Voltage Fluctuations: Sources and Effects, flicker, impulses, occurrence and causes of voltage unbalance, symmetrical components. Utility- Customer Interface-Harmonic filter, Load compensation and voltage regulation using DSTATCOM, Uninterruptible Power Sources, BESS, DVR, UPQC.

Suggested reading:

1. A. Ghosh and G. Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Acadamic.
2. G.T. Heydt. "Electric Power Quality", Stars in a Circle Publications (2nd Edition).
3. J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment, John Wiley & sons, New York.
4. Math H.J. Bollen, Understanding Power quality problems, IEEE Press, New York.
5. E. Acha, Manuel Madrigal, Power system Harmonics, John Wiley & sons, New York.
6. Moreno – Murioz (Ed), Power Quality (Mitigation Technologies in Distribution Environment Springer, 07.

7. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad,"Power Quality Problems and Mitigation Techniques", John Wiley & Sons Ltd. 2015.

PSY5408 Digital Signal Processing

Discrete Time Signals and Systems: Representation of discrete time signals- classifications-Discrete time systems, Discrete Fourier transform properties. Fast Fourier transform- Z- transform, structure realization, direct form- lattice structure for FIR filter- Lattice structure for IIR Filter. Design of Filters: FIR Filter- windowing technique- optimum equiripple linear phase FIR filter- IIR filter- Bilinear transformation technique- impulse invariance method- Butterworth filter- Tchebyshev filter. Multistage representation: Sampling of band pass signal- antialiasing filter – Decimation by an integer factor- interpolation by an integer factor- sampling rate conversion – implementation of digital filter banks- sub-band coding- Quadrature mirror filter Digital Signal Processors, Fundamentals of fixed and floating point DSP architecture.

Suggested Readings:

1. John G.Proakis, Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorthms and Applications", PHI.

2. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing" TMH.

3. A.V. Oppenheim and R.W. Schafer, Englewood "Digital Signal Processing", Prentice-Hall, Inc.

4. Rabiner and Gold, "Theory and Application of Digital Signal Processing",

5. B. Venkatramani & M. Bhaskar, "Digital Signal Processors architecture, programming and applications", TMH.

PSY5410 High Voltage DC Transmission

DC power transmission technology introduction-comparison of ac and dc transmission –application of dc transmission-description of dc transmission system, planning for hvdc transmission-modern trends in dc transmission analysis of hvdc converter pulse number, choice of converter configuration-simplified analysis of graetz circuit-converter bridge characteristics, characteristics of twelve pulse converter –detailed analysis of converters.converter and hvdc system control.general principles of dc link control- converter control characteristics-system control hierarchy –firing angle control-current and extinction angle control-starting and stopping of dc link power control –higher level controllers-telecommunication requirements.harmonics and filters. introduction-generation of harmonics-design of ac filters-dc filters-carrier frequency and RI noise. simulations of hvdc systems introduction – system simulation: philosophy and tools-hvdc system simulation-modeling of hvdc systems for digital dynamic simulation.

Suggested reading:

1. Padiyar, K.R. "HVDC power transmission systems", Wiley Eastern Limited, New Delhi 1990. First edition.

2. Edward Wilson Kimbark, "Direct Current Transmission", Vol. I. Wiley Interscience, New York, London, Sydney,1971.

3. Arrillaga, J., "High Voltage Direct Current Transmission", Peter Peregrinus, London,1983.

PSY 5302 Minor Project

PSY5304 Intelligent Control Techniques

Fuzzy Logic Systems: Fuzzy sets, operations on fuzzy sets, fuzzy relations, operations on fuzzy relation, linguistic variables, fuzzy if-then rules, compositional rule of inference, fuzzy reasoning. Fuzzy Logic Control: Basic concept of fuzzy logic control, reasoning with an FLC, relationship to PI, PD and PID control, design of FLC:determination of linguistic values, construction of knowledge base, inference engine, tuning, fuzzification and defuzzification, Mamdani type models, Takagi-Sugeno-Kang (TSK) fuzzy models Artificial Neural Networks: Perceptron, perceptron training rule, gradient descent rule, multilayer networks and backpropagation algorithm, convergence and local minima, regularization methods, radial basis function networks, alternative error minimization procedures, unsupervised networks. Neural Networks for feedback Control, Neural Network Reinforcement Learning Controller, Adaptive Reinforcement Learning Using Fuzzy Logic Critic, Optimal Control Using NN Hybrid algorithms, ANFIS and extreme- ANFIS, derivative free optimization methods, genetic algorithm, particle swarm optimization, Solution of typical control problems derivative free optimization.

Suggested reading:

1. Christopher M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press New York 1995
2. S. Haykin, "Neural Networks and Learning Machines" (3rd Edition), Prentice Hall 2009
3. Driankov, Hellendoorn, Reinfrank, "An Introduction to Fuzzy Control", Narosa Publishing House 1993
4. Timothy J. Ross., "Fuzzy Logic with Engineering Applications", 3rd edition John Wiley and Sons 2011
5. SR Jang, CT Sun, E Mizutani "Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence", Prentice-Hall of India 2004

PSY5306 Analog Filter Design

Introduction to modern active building blocks used in Analog Filters: Current Conveyors, Operational Transconductance Amplifiers, Current Feedback Amplifiers, OTRAS, CDBAS and other modern devices. First order filters: Realization with passive elements, realization with active elements, cascaded design Second order LP and BP filters: Design parameters, the 2nd order circuits, KHN, Biquads, S & K Biquads, SAB biquads and GIC circuits. LP filters with maximally flat and equal ripple response, inverse Chebyshev and Cauer filter. Frequency transformation: LP-HP, LP-BP, LP-BE, etc. LC, Ladder filters, Ladder Simulation by element replacement, GIC embedding technique, FDNR technique, creation of negative components, Gm-C & switched capacitor filters, sensitivity considerations.

Suggested Readings:

1. R. Schaumann & M.E. Vanvalkenburg, "Design of Analog Filters", First Edition, Oxford, 2001.

PSY5308 Dynamics of Synchronous Machines

Synchronous Machines Dynamics: Causes of Disturbances, Electromechanical equations, Operation as generator and motor, linearized analysis, Cyclic Variation of shaft torque, Large Angular oscillations, Equal area criterion, Hunting in Synchronous Machines, Synchronous Machine

Modelling: Mathematical Description of a Synchronous Machine: Basic equations of a Synchronous Machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dqo-Transformation: flux linkage and voltage equations for stator and rotor in dqo-coordinates, electrical power and torque, physical interpretation of dqo -transformation, Per Unit Representation: Lad reciprocal per unit system and power – invariant form of Park's transformation; Equivalent circuit, computation of steady-state values, Swing equation, H- constant and D constant calculation, Representation in system studies, Synchronous Machine Representation in Stability studies; Simplified model and two-axis model with amortisseur windings neglected. Dynamic performance - three phase fault, transient stability limit, critical clearing time, computer simulation.

Suggested reading:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition.
2. Samuel Seely, "Electromechanical Energy Conversion: Electric Machinery", TataMcGraw Hill, 5th Edition.
3. L.P. Singh, "Advanced power System Analysis and Dynamics", Wiley Eastern Limited

PSY5310 Smart Grid

Introduction: Structure and Fundamental Problems of Electrical Power Systems, Principles of Electrical Power Control, Power Flow Control, Distributed Generation and Energy Storage, Benefits to Grids, Damping of System Oscillations, Power Quality Control, Fully Integrated Power System-Smart Grid, Smart Electrical Energy Networks Concept-Microgrids & Picogrids. Microgrid configuration and interconnection, Technical advantages and challenges of Microgrid. Distribution system and operational issues of Microgrid, power quality, Ride through, Grid synchronization. Network management needs of Microgrid, Microsource generation control, Domestic process control, Energy storage, Regulation and load shifting, Microsource controller, Decentralized Operation, Protection co-ordination, Grid Synchronization. PWM Rectifiers, Multilevel Converters, Neutral point Clamped VSC, space vector PWM, Z-source converters, Three level and Four wire inverters with z source, Grid-imposed Frequency VSC system control , D-STATCOM, SSSC, UPFC, Back to Back HVDC Conversion Systems, Bricks-Buses-Software (BBS). SCADA and control of DNO SCADA systems (Centralised & Distributed).

Suggested reading:

1. Mini S. Thomas, John Douglas McDonald, "Power System SCADA and Smart Grids", CRC Press 2015.
2. S. Chowdhary, S. P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Network", IET, 2009
3. R. Strzelecki, G. Benesek, "Power Electronics in Smart Electrical Energy Networks", Springer, 2008
4. Amirnaser Yazdani & Reza Iravani, "Voltage Sourced Converters in Power Systems: Modeling, Control, and Applications", IEEE Press, 2010.
5. Nick Jenkins et al., "Embedded Generation", IET, 2000.

PSY5202 Restructured Power Systems

Market Models, Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world. Perceptrons Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. - Ancillary Services for Restructuring-Automatic Generation Control (AGC). Introduction-Components of restructured system-Transmission pricing in Open-access system-Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management – Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods Open Access Distribution - Changes in Distribution Operations- The Development of Competition –Maintaining Distribution Planning Power Market Development – Electricity Act, 2003, Developing power exchanges suited to the Indian market – use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market- Online power trading.

Suggested reading:

1. Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & Sons Ltd., 2001.
2. Mohammad Shahidehpour, Hatim Yamin, "Market operations in Electric power systems", John Wiley & son ltd., 2002
3. Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation' Taylor & Francis, 2006.
4. Mohammad Shahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, Inc., 2001.

PSY5204 Power System Planning

Introduction-Power system planning, power system development and growth, power sources, planning tools. Electricity regulations. Electricity Forecasting. Generation Planning. Transmission and distribution network planning. New operation and planning policies. Allocation of reserve. Demand side bidding. Pricing schemes. Competitive electricity markets. Environment effects. Technology and Innovation (Modern Trends).

Suggested reading:

1. Sullivan-"Power System Planning"., McGraw Hill.
2. Pabla, A.S., "Electric Power System Planning", Macmillan, India.

PSY5206 Machine Learning

Introduction to Machine Learning, Unsupervised, Supervised, Reinforcement, Hybrid models. Decision Boundaries: crisp, and non-crisp, optimisation problems. Unsupervised Learning: K-Means, Gaussian Mixture Models, EM. ML-Estimation: the simple case of one 1-D Gaussian, to the general case of K D-dimensional Gaussians. Eigen Analysis: PCA, LDA and Subspaces. Linear Models for Regression, Classification. The basic SVM optimisation: the primal and the dual problems

Suggested reading:

1. C. M. Bishop. "Pattern Recognition and Machine Learning". First Edition. Springer, 2006. (Second Indian Reprint, 2015).
2. P. Flach. "Machine Learning: The Art and Science of Algorithms that Make Sense of Data". First Edition, Cambridge University Press, 2012.
3. S. J. Russell, P. Norvig." Artificial Intelligence: A Modern Approach." Third Edition, Prentice-Hall, 2010.
4. Y. S. Abu-Mostafa, M. Magdon-Ismail, H.-T. Lin. "Learning from Data: A Short Course." First Edition, 2012.

PSY5208 PMU and Advanced Metering

Synchrophasor technology; Time-synchronized concepts and measurements, synchrophasor application in power system; Global Positioning System (GPS); PMU and it's principle of operation; PMU specifications, selection of locations; Phasor Data Concentrator (PDC); Wide Area Measurement system(WAMS) and monitoring concepts; State estimation (SE) and visulization of state estimators; PMUs for rotor angle stability, voltage stability, fault assessments and oscillation monitoring. Advanced metering infrastructure (AMI) and benefits, AMI System requirements and key components; Automated meter reading (AMR) network topology; TOD metering, Net Metering, Head-end-system; Differences between AMI and AMR; Wireless and wired communications (viz. PLCC,RF, WiFi, Optical fibre communication); Walk-by, drive-by and fixed network methods for data collection, communication flows; communication latency; advanced SCADA.

Suggested Readings:

1. Synchronized Phasor Measurements and Their Applications by Arun G Phadke, James S Thorp, Springer, 2017.
2. Power System Grid Operation Using Synchrophasor Technology, Edited by Nuthalapati, Sarma, Springer, 2019
3. Phasor Measurement Units and Wide Area Monitoring Systems by Antonello Monti , Carlo Muscas, Ferdinanda Ponci , Kindle Edition.
4. PMU Placement in Power System Network: A case Study by Ashish Mishra, Publisher: Lambert, May 2017
5. Power System Stability and Control by P. Kundur, McGraw-Hill, New York, 1994.
6. Application of Time-Synchronized Measurements in Power System Transmission Networks by Mladen Kezunovic, Sakis Meliopoulos, Vaiyhianatham Venkatsubramanian,Vijay Mittal, Springer, 2014.
7. Advanced Metering Infrastructure (AMI) by Gerardus Blokdyk , Third Edition, Nov 2018, Publisher: 5starcooks.
8. The 2018-2023 World Outlook for Advanced Metering Infrastructure (AMI) by Icon Group International, Publisher: ICON Group International, Inc.,December, 2017.

PSY5210 EHV AC Power Transmission

Introduction Standard transmission Voltages- average values of line parameters- Power handling capacity and line loss, Costs of transmission lines and equipment, Mechanical consideration in line performances. Corona Effects- Power losses and audible noise, I2R losses and corona loss, Attenuation of travelling waves due to corona loss, Audible noise generation and characteristics, limits of audible noise, Day Night equivalent noise level, Radio Interference, corona pulse generation and properties, Limits for Radio Interference Fields, CIGRE formula, RI excitation function, Measurement of RI, RIV and excitation function, Design of Filter. Electrostatic Field of Ehv Lines – Capacitance of long object, calculations of electrostatic field of AC lines, effect of high electrostatic field on humans, animals and plants, Measurement of electrostatic field, electrostatic induction in unenergised circuit of DC line, Induced voltages in Insulated ground wires, electromagnetic interference. Compensation of Ehv Lines- Series and shunt compensation, problems due to series compensation, Sub-synchronous resonance and remedial measures.

Suggested reading:

1. Begamudre, R.D., EHVAC Transmission Engineering, New Age .
2. Padiyar, K.R., HVDC Power Transmission Systems, Wiley Eastern Ltd.
3. Kimbark, E.W., Direct Current Transmission, John Wiley, U.S.A.
4. Power Engineer's Handbook, Revised and Enlarged 6th Edition TNEB Engineer's Association, October 2002.

SEMESTER III

PSY6401 SCADA and Energy Management Systems

Concept of Supervisory control & Data Acquisition System, Component and types of SCADA systems, CT, PT, Voltage to current, current to voltage converters, RTUs etc. Supervisory and control functions, man-machine communication, operator console, VDU display and its use, operator dialogues, mimic diagram functions, printing facilities etc. SCADA system structures, system classes, system interactions, performance criteria, software and hardware considerations, data bases, reliability and simulations, technical realizations, local system, communication system, central system, control system supervision & system maintenance. Application functions-real time network modeling, security management, production control and training simulators.

Introduction to communication systems, Hotline, PLCC, Mobile, Satellite, Microwave & Optical fibre communications. Transputerised SCADA system, SCADA on embedded FPGA.

Suggested Reading:

1. Krishana Kant, "Computer-based Industrial Control", PHI Publication.
2. Liptak, "Process Control", CRC Publication.
3. Madiseth & Williams, "Digital Signal Processing", CRC Press, IEEE Press.
4. Kissel, "Industrial Electronics", PHI Publication.
5. Mini S. Thomas, John Douglas McDonald, "Power System SCADA and Smart Grids", CRC Press 2015.

PSY6403 Computer Aided Power System Analysis

Sparsity Techniques: Storage of sparse matrix, Sparsity directed inversion methods and parallel inversions.

Load Flow with HVDC Link: Balanced AC load flow, DC system model, incorporation of control equations, inverter operation, unified and sequential solution techniques.

Three-phase Load Flow: load flow equations, solution techniques- Gauss-Seidal, Newton Raphson methods and fast decoupled method; Three-phase AC-DC load flow Short Circuit Studies for Unbalanced Network: Z-bus building algorithm; Derivation of fault admittance matrices, three-phase model of transmission lines- series and shunt impedance, mutually coupled three-phase lines, transformer modeling, sequence components, analysis of unbalance faults, open circuit fault, three-phase model of sysnchronous machine.

State estimation and bad data processing: State estimation of linear and nonlinear systems, Pseudo-measurements, recursive and weighted least square estimation method, detection and identification of bad measurements, network observability.

Reactive power allocation and scheduling: sources of reactive power reactive power capability curve FACT devices modeling of reactive power allocation problem solution techniques.

Suggested reading:

1. Abur A. and Exposito A. G., Power System State Estimation: Theory & Implementation, Marcel Dekkar 2004.
2. Arrillaga J. and Watson N.R., " Computer Modelling of Electrical Power Systems, John Wiley & Sons 2003.
3. Wood A. J. and Wollenberg B.F., " Power Generation, Operation and Control, John Wiley & Sons.

PSY6405 Microcontroller and Embedded Systems

Organization of a microprocessor, register organization, C.P.U., Description of timing and control units, interfacing memory & I/O devices, Synchronous & Asynchronous data transfer, Interrupts, Polling, DMA, Introduction to Pentium and Pro-Pentium microprocessors. Basic organization of 8051, 8097, PIC, SLK-51 microcontrollers, instruction set - timing diagram, address modes, simple program and applications.

Embedded system and their components, categories of embedded systems. Stand alone, Real time Networked and Mobile etc., Requirements of embedded systems. Reliability, cost effectiveness, low power consumption, efficient use of processing power, efficient use of memory, approximate execution time, challenges and issues in embedded software development. Co design operating system, efficient I/O testing and debugging.

Hardware Architecture for embedded systems, Embedded Applications.

Suggested reading:

1. John B. Peatman, "Design with Microcontrollers", McGraw Hill International Ltd, Singapore, 1989.
2. Intel manual on 16 bit embedded controllers, Santa Clara, 1991.
3. Myko Predko. 'Programming and customizing the 8051 micro controller', Tata McGraw Hill, 1999.

4. Muhammad Ali Mazidi, Janice Gillispie Mazidi. 'The 8051 Microcontroller and Embedded systems', Pearson Education, 2004.

5. Michael Slater, "Microprocessor based design: A Comprehensive guide to effective hardware design", Prentice Hall, New Jersey, 1989

6. John B. Peatman, "Design with PIC Microcontrollers", Pearson Education Asia 2004

PSY6407 Advanced Electric Drives

Review: Power electronic converters for ac drive control, voltage source and current source inverters LCI-IM Drive: Drive configuration, commutation at different speeds, mathematical modeling, control structure, resonance problem and performance. FOC-IM Drive: Drive configuration, mathematical modeling, direct and indirect FOC, influence of parameters, VSI and CSI fed schemes, adaptive drive control Brushless DC Drive: Self control, CSI with load commutation, low speed commutation, inverter control strategies and performance Permanent Magnet SM Drive: Principle of operation, converter configuration, synchronization, trapezoidal and sinusoidal drive control structures and performance. Switched Reluctance Motor Drive: Principle of operation, converter circuits, sensors, speed control and performance. Resonant-Link Converter fed Drive: Principle of soft switching in inverters and converters utilizing resonant circuits, modulation strategies and application in IM drives Advanced Control Techniques: Application of modern and evolutionary techniques in drives such as fuzzy and ANN control.

Suggested reading:

1. Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa 2007 Publishing House.

2. Pillai S. K., "A First Course in Electric Drives", 2nd Ed., New Age 2008 International Private Limited.

3. Mohan N., Undeland T.M. and Robbins W.P., "Power ElectronicsConverters, Applications and Design", 3rd 2008 Ed., Wiley India

4. Dubey G. K., "Power Semiconductor Controlled Drives", PrenticeHall International Editions. 2001

5. Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Pregamon Press. 1990

6. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors. 2001

7. Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited. 2007

PSY6301 Power System Reliability

Basic probability theory, review of concepts, probability distributions. Markov processes, State Transition Matrix and state Transition Diagram. Definition of Reliability, general reliability function, evaluation of reliability using state enumeration. Tie set and cut set method. Reliability indices from state transition matrix and state transition diagrams. Models for generation system reliability evaluation, loss of load indices, loss of energy indices, frequency and duration methods. Reliability evaluation of two area interconnected system. Conditional probability approach for reliability evaluation of a generation-transmission system. Transmission system reliability evaluation using average interruption rate method and frequency and duration methods. Evaluation of interruption indices for radial distribution systems. Introduction to protective system reliability evaluation.

Suggested reading:

1. Billington, Ringley & Wood, "Power System Reliability Calculation", MIT Press.
2. Endeerny, J, "Reliability Modelling in Power System", John Wiley, NY.

PSY6303 Transients in Power Systems

Origin and nature of transients and surges. Fundamental concepts of RLC circuit analysis, application of Laplace transform, Simple switching transients, Effect of resistance on LC circuit transients, Abnormal switching transients, Transients in three-phase circuits, Travelling waves on transmission lines, Lightening, Insulation coordination, Overvoltage protection, substation equipment, Lumped and distributed circuit representations. Line energization and de-energization transients, current chopping, short-line faults, trapped charge effects, effect of source, control of transients, Lightening, effect of tower footing resistance, travelling waves, insulation coordination, circuit breakers duty, surge arresters, overvoltage limiting devices, Case studies.

Suggested reading:

1. Allan Greenwood, Electrical Transients in Power Systems, Wiley-Blackwell; 2nd Edition, 1991.
2. Pritindra Chowdhuri, Electromagnetic Transients in Power Systems (High-Voltage Power Transmission), 2nd edition, PHI Learning

PSY6305 Advanced Distribution Systems

Introduction to distribution systems. Nature of load and load modeling, 3 phase transformer modeling Distribution system load flow for balanced and unbalanced system radial and weakly meshed systems (with and without PV buses) Short circuit analysis of distribution systems

State estimation of distribution systems Basics of distribution system reliability Voltage regulation in distribution systems Distribution system protection issues Distributed generation integration issues in distribution system

Suggested reading:

1. Kersting W. H, "Distribution system modeling and analysis", CRC press,New York, 2002
2. Brown R. E., "Electric power distribution reliability (second edition)", CRC press, New York, 2009
3. Northcote-Green J. and Willson R., "Control and automation of electric power distribution systems", CRC press, New York, 2007
4. Chowdhury A. A. and Koval D. O., "Power distribution system reliability practical methods and applications", Wiley IEEE press, 2009

PSY6307 Grid and Sub-Station Planning and Technologies

Transmission Planning and security criteria; Load-generation balancing; Transmission network expansion and selection of EHVAC and HVDC Voltages; SIL, thermal loading and stability constraints; Overhead transmission line routes and Right of-ways; EHV cables and overhead conductor technologies; Series and shunt reactive power compensation/planning; Inter-area/region transmission planning; Grid connectivity planning for RESs; Transmission planning studies (Load flow ,short circuit, stability)

AIS, GIS, Hybrid sub-stations of medium to high AC Voltages, Generation Switchyard, HVDC

switchyard, sub-station layouts, sub-stations capacity and design principle, Busbar topologies, CT, PT,CVT, Lightning Arrestor, Circuit Breakers, Bus bar protection, short-circuit levels and its limitations, Earth Mat, Bus splitting/sectionalization, Fault current limiters, Bay width and clearances, Static and dynamic reactive power compensation, Filters and land requirements.

Suggested reading:

1. Power System Stability and Control by P. Kundur, McGraw-Hill, New York, 1994.
2. Understanding FACTS by Narain G. Hingorani and Laszlo Gyugyi, IEEE Press,Standard Publishers.
3. Power system voltage stability by Carson W. Taylor, McGRAW-HILL,Inc.
4. Modern Power system Analysis by D P Kothari and I J Nagrath.
5. An introduction to Reactive Power control and Voltage stability in Power Transmission System by A. Chakraborti D.P. Kothari, A.K. Mukhopadhyay, Abhinandan DE
6. Fundamentals of Modern Electrical Substations (Kindle Edition) by Boris Shvartsberg
7. Short Circuit Currents in three-phase Systems by Richard Roeper,Wiley Eastern Ltd.
8. International Council on large Electric Systems (CIGRE) Study committee B3: Substations, CIGRE Green Book, Editors Terry Kreig & John Finn, Springer,2019.
9. Electric Power Substations Engineering,3rd Edition, Edited by John D. McDonald, CRC Press.

PSY6309 Modern Electric Traction System

Introduction to Railway Traction Systems Choice of traction system. General arrangement of D.C.traction system, A.C.single phase, 3phase systems, Composite systems Mechanics of Train Movement Analysis of speed time curves for main line, suburban and urban services, Simplified speed time curves., Traction Motors and Their Control Features of traction motors, Significance of D.C. series motor as traction motor, A. C. Traction motors-single phase, Three phase, Linear Induction Motor, Types of electric braking system. Important features of electric locomotives, Different types of locomotives, Current collecting equipment, Power conversion and transmission systems, Control and auxiliary equipment. Feeding and Distribution System. Distribution systems pertaining to traction (distributions and feeders), Traction sub-station requirements and selection, Method of feeding the traction sub- station Latest Trends in Traction system Present scenario– High speed traction, Metro, Latest trends in traction-Metro, monorail, Magnetic levitation Vehicle.

Suggested reading:

1. Modern Electric Traction, H. Partab, Dhanpat Rai and Sons, New Delhi
2. Electric Traction, A.T. Dover, Mac millan, Dhanpat Rai and Sons, New Delhi
3. Electric Traction Hand Book, R. B. Brooks Sir Isaac Pitman and sons ltd. London
4. Electromagnetic Compatibility in Railways Analysis and Management, Ogunsola

PSY6201 Energy Auditing and Conservation

Introduction to energy audit, energy management approach, understanding energy cost bench marking, energy performance matching energy usage to requirement maximizing system efficiency optimizing the input energy requirement fuel and energy substitution. Energy management and conservation in domestic sector. Energy management in small, medium and large HT industries.

Demand and Supply side management. Energy Audit, Energy Audit measuring tools. Distribution system and Transmission system planning with respect to loss reduction. Energy saving opportunities in electric motors benefits of power factor improvement and its techniques effect of harmonic on motors and remedies leading to energy conservation methods and techniques of energy conservation in ventilation and air conditioners electric furnace oven and boilers lighting welding and traction.

Suggested reading:

1. Steven R Patrick Dale R Patrick Stephen W Fardo " Energy conservation guidebook" The Fairmont Press, Inc 1993
2. S C Tripathy "Electric Energy Utilization and Conservation" Tata Mcgarw Hill india 1991.
3. IEEE Bronze book IEEE standard 739-1995-IEEE recommended practice for energy management in industrial and commercial facilities.1996
4. Books of energy management and auditors bureau of energy efficiency, http://beeindia.in/ volume1,2,3& 4
5. Sunil S Rao " Utilization generation and conservation of electrical energy" Khanna publishers India 2011

PSY6203 Electricity Market and Regulations

Electricity Market Structure, Power Exchanges and its working principle for power trading, Power traders, electricity market clearing methodology, Power Purchase Agreements, Electricity pricing and trading, Demand side Management, Load frequency control, Long term- medium- short term open access in transmission, Grid connectivity, Bilateral contracts, Intraday, day ahead and spot market, Spot and day energy accounting, , Ancillary Services, Electricity Market Operators and Regulators, Regulations of electricity Utilities, T&D loss optimization, Integrating must run generation from RESs.

Suggested reading:

1. Fundamentals of Power System Economics by Daniel Kirschen & Goron Strbac, John Wiley & Sons, Ltd
2. Operation of Restructured Power Systems by Kankar Bhattaccharya, Math H. J.Bollen & Jaap E. Daalder, Kluwer Academic Publishers.
3. Compendium of Regulations, Central Electricity Regulatory Commission, New Delhi.

PSY6205 Digital Communication

Review of random variables and random process, signal space concepts, Common modulated signals and their power spectral densities, Optimum receivers for Gaussian channels, Coherent and non-coherent receivers and their performance (evaluating BER performance through software tools), Basics of Information theory, source and channel coding, capacity of channels, band-limited channels and ISI, multicarrier and spread spectrum signalling, multiple access techniques

Suggested reading:

1. John G Proakis and Salehi, Digital Communication, Fifth Edition, McGraw-Hill, 2007.
2. 2. John R. Barry, Edward A. Lee, David G. Messerschmitt, Digital Communications, Springer, third edition, 2004

PSY6207 Energy Ecology and Environment

Environment definition, Environmental Segments, Fundamentals of Ecology and Ecosystem, Components of ecosystem, Food chain, Food web, Trophic level, Energy flow. Introduction, types, characteristic features, structure and function of the following ecosystem: Forest, Grassland, Desert and Aquatic ecosystem. Effects of human activities on environment: Agriculture, Housing, Industry, Mining and Transportation activities, Basics of Environmental Impact Assessment & Sustainable Development. Water Resources - Availability and Quality aspects. Mineral Resources, Soil, Material cycles- Carbon, Nitrogen and Sulphur Cycles. Energy - Different types of energy, Conventional and Non-Conventional Sources. Gas Hydrates, Hydrogen as an alternative future source of Energy. Definition causes effects and control measures of: Air Pollution, Water pollution, Land pollution, Noise pollution. Climate Change and Global warming: Effects, Acid Rain, Ozone Layer depletion, Photochemical Smog, Solid waste management, Waste water treatment. Ambient air quality standards, Water quality parameters and standards.

Suggested Readings:

1. James Girard 'Principles of Environmental Chemistry', Jones & Bartlett Learning, 2005
2. Benny Joseph 'Environmental Studies', Tata McgrawHill, 2005.
3. A K De 'Environmental Chemistry' New Age International Publishers, 2005.
4. D.D. Mishra, S.S. Dara 'A Textbook of Environmental Chemistry and Pollution Control (With Energy, Ecology, Ethics and Society)', S. Chand and Co, 2004.
5. Samir K. Banerjee 'Environmental Chemistry' Prentice Hall of India, 2009.
6. P. Venugoplan Rao 'Principles of Environmental Science and Engineering' Prentice Hall of India, 2006.
7. D.L. Manjunath 'Environmental Studies' Pearson Education, 2006.

PSY6209 Artificial Intelligence

Introduction, philosophy of intelligent agents; uninformed search; heuristic search; local search; constraint satisfaction; logic and satisfiability; adversarial search; classical planning; decision theory; Markov decision processes; Bayesian networks representation, inference and learning; reinforcement learning; basics of supervised, semi-supervised and unsupervised learning; intro to NLP; intro to information retrieval; submodularity; current research trends.

Suggested Readings:

1. Stuart Russell & Peter Norvig, "Artificial Intelligence: A Modern Approach", Prentice-Hall, Third Edition (2009)
2. C. M. Bishop, "Neural Networks for Pattern Recognition" Oxford University Press 1995.
3. T. Dean, J. Allen, & Y. Aloimonos, "Artificial Intelligence theory and practice.", Benjamin Cummings, 1995.

Semester IV

PSY652 Research Project

PSY602 Major Project II

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Environmental Engineering)

Programme Specific Outcomes

1. Enhancing the employbility skills by making the students capable of qualifying National level competitive examinations.
2. Competency in professional and Industrial areas
3. Inculcating human values and ethics, tech-savviness and self-learning to deal with challenges of Environmental Engineering.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN ENVIRONMENTAL ENGINEERING (ENE)

The following alphanumeric coding scheme has been adopted: Core Courses XXXYMN; Elective Courses XXXYCMN

XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1st year, 6 for M. Tech. 2nd year); C – credit of the course (4/3/2); MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	ENE501	Water Pollution	Core	4	3	0	2	15	25	20	40	-	17
	2	ENE503	Air Pollution & Control	Core	4	3	0	2	15	25	20	40	-	
Group B	3	ENE5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	ENE5301/5303/.....	Elective 2	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	5	ENE5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	ENE502	Water Engineering Design	Core	4	3	0	2	15	25	20	40	-	17
	2	ENE504	Solid Waste Management	Core	4	3	0	2	15	25	20	40	-	
Group D	3	ENE5402/5404/5406	Elective 4	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	ENE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	ENE5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	Track 1													
Group E	1	ENE651	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	ENE601	Major Project I	Core	3						40	60		12
	2	ENE6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	3	ENE6301/6303/.....	Elective 8	Elective	3	3/2	0	0/2	20/15	0/25	30/20	50/40	-	
	4	ENE6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													
	1	ENE652	Research Project	Core	12	0	0	12	0	-	0	100	0	12
	Track 2													
	1	ENE602	Major Project II	Core	12	0	0	12	0	-	0	100	0	12

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	ENE5401	Industrial Wastewater Treatment	Elective	4	3	0	2	15	25	20	40	-
	2	ENE5403	Planning & Design of Environmental Services		4	4	0	0	20	-	30	50	-
	3	ENE5405	Groundwater & Seepage		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	ENE5301	Environmental Chemistry & Microbiology	Elective	3	2	0	2	15	25	20	40	-
	2	ENE5303	Occupational Safety & Health		3	3	0	0	20	-	30	50	-
	3	ENE5305	Instrumentation		3	2	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	ENE5201	SEMINAR	Elective	2	0	0	2	-	100	-	-	-
	2	ENE5203	Advanced Mathematics & Statistics		2	2	0	0	20	-	30	50	-
	3	ENE5205	Design of Hydraulic Structures		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	ENE5402	Global Warming & Climate Change	Elective	4	4	0	0	20	-	30	50	-
	2	ENE5404	Waste Containment & Remediation Technology		4	3	0	2	15	25	20	40	-
	3	ENE5406	Environmental Planning & Management		4	4	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	ENE5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	ENE5304	Environmental Monitoring & Assessment		3	3	0	0	20	-	30	50	-
	3	ENE5306	Green Technology & Sustainability		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	ENE5202	Environmental Policy & Law	Elective	2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	ENE6401	Environment Impact Assessment &Audit	Elective	4	4	0	0	20	-	30	50	-
	2	ENE6403	Remote Sensing & GIS		4	3	0	2	15	25	20	40	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	ENE6301	Air Quality Modeling	Elective	3	2	0	2	15	25	20	40	-
	2	ENE6303	Life Cycle Assessment		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	ENE6201	Hazardous Waste Management	Elective	2	2	0	0	20	-	30	50	-
	2	ENE6203	Bioremediation		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

ENE501 Water Pollution

Water quality, Detection and measurement of water pollution, stream surveillance, standards and criteria of water quality, water quality management for different uses, Eutrophication and its control strategies, heavy metal pollution and its remediation, Modelling approaches to water quality, River Water quality modelling; modelling in lakes and reservoirs, Modelling of DO in streams, models for microbial decay, Disposal of waste water, Management of Water Pollution

Suggested Books:

1. Manahan, Environmental Chemistry, CRC Press Book
2. Sawyer, McCarty, and Parkin, Environmental Engineering, McGraw-Hill
3. Berry WK, Water Pollution, CBS Publishers

ENE503 Air Pollution & Control

Definition, Sources of air pollution, air pollution measurement, estimation of air pollution sources, effects of air pollution. air quality standards. air pollution meteorology, dispersion of air pollutants. air pollution control equipment: settling chambers. Inertial devices, electrostatic precipitator, scrubbers, fitters, adsorption devices, combustion devices, condensation devices, Basics of acoustics, sound power, sound intensity, sound pressure level, measurement of noise, noise mapping, noise standards, health effects of noise, basic knowledge about noise models, noise control methods.

Suggested Books:

1. Rao CS, Air Pollution and Control, New Age International Pvt Ltd
2. Rao and Rao, Air Pollution Control Engineering, McGraw Hill Education

Nathanson JA, Basic Environmental Technology: Water Supply, Waste management and Pollution Control, Fifth Edition PHI

ENE5401 Industrial Wastewater Treatment

Theories of waste water treatments, combined treatment of raw industrial waste with domestic sewage, volume reduction, strength reduction, Discharge of completely treated waste to Municipal Sewer, discharge of raw waste to stream, standards for discharge of treated wastewater, characteristics and treatment of wastes from the apparel industry, Food processing industries, Material industries, Chemical industries, Energy industries CETP-case studies.

Suggested Books:

1. Patwardhan AD, Industrial wastewater treatment, PHI Learning Pvt. Ltd.
2. Karia GL & Christian RA Wastewater Treatment, PHI Learning Pvt. Ltd.
3. Arundel J, Sewage and Industrial effluent treatment, Blackwell Science

ENE5403 Planning & Design of Environmental Services

Environment and Human-Activity: Resource, pollution, re-use & management; Land-Use Planning & Management; Water plan optimization & allocation; Design of conveyance system for source and fugitive, Design of cyclone and cyclone scrubbers, venture-scrubbers, packed towers and fabric filters. Design of control for volatile organic carbon compounds; Management of private and public managed utilities, management of water supply and sewerage schemes, Environmental objectives and targets, utilities equipment maintenance and preventive maintenance.

Suggested Books:

1. Gilbert MM, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd.
2. Canter, Environmental Impact Assessment, McGraw-Hill
3. Rao & Rao, Air Pollution, Tata Mcgraw Hill

ENE5405 Groundwater & Seepage

Darcy's law General hydro-dynamic equations, flow nets in isotropic and anisotropic medium. Steady and unsteady flow through confined and non-confined aquifers, Schwartz Christoffel transformation and its application for ground water and seepage problems. Multiple well system, partially penetrating wells, image wells, mutual interference of wells. Storage and exploration of ground water, design, construction and maintenance of wells. Ground water recharge and run off. Water quality, budgeting, simulation of ground water basin. Application of remote sensing for ground water.

Suggested Books:

1. Cushman & Tartakovsly, The Handbook of groundwater Engineering, CRC Press
2. Milton Edward Harr, Groundwater and Seepage, McGraw-Hill
3. Delleur JW, Handbook of Groundwater Engineering, CRC Press

ENE5301 Environmental Chemistry & Microbiology

Hydrological cycle, unique properties of water, principles of equilibrium chemistry, pH, oxidation-reduction and their application; chemistry of pollution due to detergents, pesticides, polymers, trace organics, metals, hydrocarbons, and radioactive compounds; chemistry of ozone depletion, smog formation; greenhouse effect; morphology of bacteria, fungi, algae; pure and mixed cultures; microbial growth and dynamics; biodegradation and basic principles of microbial transformation of organic matter; acclimatization of wastes and microbial inhibition mechanisms; Role of microbes in wastewater treatment; Microbiology applied to bio scrubbers and bio filters, bioremediation of contaminated sites-case study.

Suggested Books:

1. Manahan, Environmental Chemistry, CRC Press
2. Gilbert MM, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt.Ltd
3. Pelczar, Textbook of Microbiology, McGraw-Hill Education

ENE5303 Occupational Safety & Health

Definition; Occupational Health and Environmental Safety Management – Principles practices. Common Occupational diseases: Occupational Health Management Services at the work place; ILO and EPA Standards; Industrial Hygiene; Element of training cycle, Assessment of needs; Chemical Hazard;Evaluation and control of basic hazards; Ergonomic Hazards; Bureau of Indian standards on safety and health 14489 - 1998 and 15001 – 2000, OSHA, Process Safety Management (PSM) as per OSHA, PSM principles, OHSAS – 18001, EPA Standards, Performance measurements to determine effectiveness of PSM. Importance of Industrial safety, role of safety department, Safety committee and Function.

Suggested Books:

1. Kohn J and Friend MA, Fundamentals of Occupational Safety and Health, Government Institutes Inc.,USA
2. Reese CD, Occupational Health and Safety Management: A Practical Approach (Third Edition)
3. Kelloway, Montgomery, and Francis, Management of Occupational Health and Safety, Nelson College Indigenous Press, 2013

ENE5305 Instrumentation

The Significance and Application of Measurement; Functional Elements of Generalized Measuring System; Classification of Measuring Instruments, Standards of Measurement and its classification; Management of Data in quantitative analysis: Accuracy, precision, types of errors, Minimization of error, statistical analysis and curve fittings; Spectro-analytical Methods; Chromatographic Methods; Electro Analytical Methods; Continuous Monitoring instruments and their principles: NDIR for CO, Chemiluminescence analysis for NO_x and fluorescence analysis for SO_2

Suggested Books:

1. Khandpur RS, Handbook of Analytical Instruments, McGraw-Hill, 2007
2. Fritschen L, Environmental instrumentation, Springer New York
3. Down RD, Lehr JH, Environmental Instrumentation and Analysis Handbook

ENE5201 Seminar

ENE5203 Advanced Mathematics & Statistics

Numerical Methods - Partial differential equations, Newton-Raphson method, Finite difference, finite element, method of characteristics, different methods, Successive over relaxation methods. Optimization – classification and importance in Environmental Studies. Single and multivariable optimization without and with constraints. Linear Programming – different methods, linear approximation of non-linear optimization. Statistics - Significance Tests, Frequency Distribution, Characteristics of Distributions, Method of Least Squares and Regression, Multiple Regression. Probability – Concepts, Methods, Binomial, Poisson and Normal distribution, Risk and uncertainty analysis.

ENE5205 Design of Hydraulic Structures

Project planning site investigations, choice of type of dams. Cost benefit studies; Non-overflow dams: Gravity, Arch and buttress type, Rock fill and earthen dams, their design, stress analysis, stress concentration around openings; Different types of spillways and energy dissipaters, their

design. Preparation and protection of foundation for dams. Model analysis of Hydraulic structures. Instrumentation in dams. Temperature control in concrete dams.

Suggested Books:

1. Keshri DN, Analysis and Design of Hydraulic Structures, JBC Press
2. Balasubramanya N, Hydraulic Structures & Irrigation Design Drawing, Sapna Book House

SEMESTER II

ENE502 Water Engineering Design

Sources of water, necessity of treatment, Critical Water quality parameters, water quality guidelines and standards; Principles and design of aeration systems – two film theory, water in air system, air in water system. Intake structures – Different types, design criteria. Principles of sedimentation; design criteria and design of settling tanks. Principle of Coagulation and Flocculation- coagulation theory, design criteria and numerical examples. Filtration - theory of granular media filtration; Classification of filters; Adsorption; Disinfection; Water Softening; Fluoridation and defluorination; Ion Exchange-processes; Membrane Processes, Reverse osmosis; Ultrafiltration; Electrodialysis; distribution: design of various components of the distribution system. Design of the units of Water Treatment Plant

Suggested Books:

1. Davis ML, Water and Wastewater Engineering: Design Principles and Practice, McGraw Hill
2. Metcalf & Eddy Inc., Wastewater Engineering: Treatment and Reuse, McGraw Hill
3. Garg SK, Water Supply Engineering: Environmental Engineering - Vol. I, Khanna Publisher

ENE504 Solid Waste Management

Definition; Sources; Composition & Properties of Municipal solid waste. Handling & Separation of solid waste, Municipal Waste (Management & Handling Rules, 2000), Integrated solid waste management (SWM) System, Hierarchical approach for SWM; Solid waste generation; Solid Waste Collection & Transportation; Waste handling and separation; Methods of Disposal of Municipal Solid Waste; Landfills: Site selection, Site preparation, Generation, & Control of Landfill gases; Movement & control of leachate; landfill design; Long term post closure plan, Groundwater monitoring during & after closure; Transformation and recycling of waste materials; Composting; Recovery of bioenergy from organic waste. Thermal Conversion Technologies: Incineration, Pyrolysis & Gasification Systems.

Suggested Books:

1. Kreith F and Tchobanoglous G, Handbook of Solid Waste Management, McGraw Hill
2. McBean, Rovers, and Farquhar Solid Waste Landfill Engineering and Design, Prentice Hall Ptr

ENE5402 Global warming & Climate Change

Introduction to Climate Change , Climate feedback, Green-House Effect, Green House Gases (GHGs) and their Emission Sources, Quantification of CO_2 Emission, Indicators of global warming, Global Warming Potential (GWP) of GHGs, Modelling Climate change, Ozone layer depletion and its control, Impacts of climate change – Global and India, Temperature Rise, Sea Level rise, Coastal Erosion and landslides, Coastal Flooding, Kyoto Protocol – Importance, Significance and its role in Climate Change, Carbon Trading - Mechanisms , Various Models (European, Indian)

Global and Indian Scenario, Clean Development Mechanisms – Various Projects related to CO_2 Emission Reduction, Carbon Sequestration – Conventional and non-conventional techniques, Role of Countries and Citizens in Global Warming.

Suggested Books:

1. Drake F, Global Warming: The Science of Climate Change - 1st Edition, CRC Press
2. Romm JJ, Climate Change: What Everyone Needs to Know, Oxford University Press

ENE5404 Waste Containment & Remediation Technology

Sources of subsurface contamination, Mechanisms of Soil contamination; Physical-chemical and biological interactions in soils; Effect of contamination on geotechnical properties; Waste disposal on land, Site selection, Leachate and Gas Generation, Waste characterization, waste containment principles; Types of Landfills, natural attenuation landfill, Containment landfills, liner material and design of landfill elements; Landfill construction, operation and performance monitoring. Environmental monitoring around landfills; Detection, control and remediation of subsurface contamination, Various types of barrier systems; Reclamation of contaminated sites-Case Studies.

Suggested Books:

1. Reddy KR, Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies, Wiley Publisher
2. Yong RN, Geoenvironmental Engineering, Thomas Telford ltd.
3. Kreith F and Tchobanoglous G, Handbook of Solid Waste Management, McGraw-Hill Education

ENE5406 Environmental Planning & Management

Environment and Sustainable Development - carrying capacity, relationship with quality of life, carrying capacity and resource utilization. Engineering Methodology in Planning and its Limitations – carrying capacity based short and long-term regional planning. Environmental Protection - Economic development and social welfare consideration in socio economic developmental policies and planning. Total cost of development and environmental protection cost. Case studies on Regional carrying capacity. Engineering Economics – Value Engineering, Time Value of Money, Cash Flows, Budgeting and Accounting. Environmental Economics: Introduction, economic tools for evaluation, Green GDP, Cleaner development mechanisms and their applications. Environmental Audit – methods, procedure, reporting and case studies.

Suggested Books:

1. McDonough and Braungart, Cradle to Cradle: Remaking the Way We make Things, North Point Press
2. Smith S, Environmental Economics, Oxford University Press

ENE5302 Minor Project

ENE5304 Environmental Monitoring & Assessment

Introduction to multi-media sampling techniques and analytical methods for evaluation outdoor/ indoor air, soil/surfaces, and water; environmental science and industrial hygiene approaches for anticipating, recognizing, evaluating, and controlling hazards, with the primary focus on recognition and evaluation of contaminants, including data interpretation for risk reduction and regulatory compliance; environmental investigative techniques, instrument selection, and quality control, documentation, calibration, and sample management.

Suggested Books:

1. Cohrssen, Draggan, and Morrison, Environmental Monitoring, Assessment, and Management, Praeger Publisher, 1987
2. Shukla and Srivastava, Methodology of Environmental Monitoring and Assessment, Commonwealth Publishers

ENE5306 Green Technology & Sustainability

Introduction of Green protocol: Need, Goal and Limitation of Green Technology, Principles of Green Technology with their explanations and examples. Green Innovation & Sustainability: Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation, technological/environmental leap-frogging; Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agroecology and other appropriate green technologies); design for sustainability; Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP; green energy management; green product management.

Suggested Books:

1. Sivasubramanian V, Environmental Sustainability Using Green Technologies, CRC Press
2. Arceivala SJ, Green Technologies, Tata McGraw Hill 2014
3. Sharma SK, Green Chemistry for Environmental Sustainability, CRC Press

ENE5202 Environmental Policy & Law

Introduction to environmental laws in India; Constitutional provisions, Stockholm conference; Bhopal gas tragedy; Rio conference. General principles in Environmental law: Precautionary principle; Polluter pays principle; Sustainable development; Overview of legislations and basic concepts; Water Act, 1974; Water Cess Act, 1977; Legal framework on Air pollution: Air Act,1981; Environment Act, 1986; Rules and guidelines under Environment Act.

Suggested Books:

1. Bishnoi, Malik, and Garg Introductory Text of Environmental Policies and Laws, Kalyani Publishers 2002
2. Trivedy RK, Handbook of Environmental Laws, Acts, Guidelines, Compliances & Standards, BPV Publications
3. Leelakrishnan P, Environmental Law in India, Butterworths India

SEMESTER III

ENE651 Research Project

ENE601 Major Project I

ENE6401 Environmental Impact Assessment

Definition and history of environmental impact assessment, related law necessary for EIA, Objectives of Environmental Impact Assessment, Process for EIA, TOR, IEE, Components of EIA Reports;

Tools for assessment of environmental impacts: checklist, networks, matrices, overlays, baseline study, scoping & scales, network overlays, index methods. Planning of environmental Factors; Prediction and assessment of impacts on air and noise; soil and land use; water quantity and quality; Mitigation and Monitoring process for environmental impact assessment; Environmental Auditing, Impact Analysis of hydropower projects.

Suggested Books:

1. Glasson J, Introduction to Environmental Impact Assessment, Routledge Publishers 2012 (4th Edition)
2. Canter L, Environmental Impact Assessment, McGraw Hill 2014
3. Noble B, Introduction to Environmental Impact Assessment: A Guide to Principles and Practice, Oxford University Press 2015
4. Shrivastava AK, Environment Impact Assessment, APH Publishing Corporation

ENE6403 Remote Sensing & GIS

Fundamentals of Remote Sensing, Ideal Remote Sensing System, Types of Sensors, Remote Sensing Satellite – IRS and INSAT specifications, Applications of remote sensing, Digital image processing and image interpretation, GIS: Principles and applications, Components of GIS, GIS Data and Types, Sources of data, Global Positioning System (GPS), Integration of Remote Sensing and GIS, Optimal Routing of Solid wastes using GIS – Case Study. Environmental Siting of Industries and Zoning Atlas Development. Modelling of Water Distribution System using GIS – Case Study. Sustainable Urban Development Planning using GIS. Environmental Degradation Assessment using RS and GIS. Ground water vulnerability modelling using GIS.

Suggested Books:

1. Campbell JB, Introduction to Remote Sensing, Guilford Press
2. DeMers MN, Fundamentals of Geographic Information Systems, John Wiley & Sons 2008 (4th edition)
3. Reddy MA, Text Book of Remote Sensing and Geographical Information Systems BS Publication

ENE6301 Air Quality Modelling

Introduction to air pollution models. Approaches to model formulation. Criteria for model selection, Application of air pollution models, Air pollution meteorology – meteorological parameters, stability classification, plume rise, plume behaviour, dispersion parameters. Emission factor, factors affecting vehicular emissions, Basic diffusion equation, deterministic, numerical and statistical models. Introduction to boundary layer, turbulence. Physical modelling approach, stochastic modelling approach to air pollution dispersion, Theory of Gaussian plume model and its application. Introduction to indoor air quality models, Case studies.

Suggested Books:

1. Gordon G, Prentice Hall System Simulation
2. Peavy and Rowe, Environmental Engineering, TMH publications
3. Pal AS, Air Pollution Meteorology and Dispersion, Oxford University Press

ENE6303 Life Cycle Assessment

The fundamental concepts related to interaction of industrial and environmental/ecological systems, sustainability challenges facing the current generation, and systems-based approaches required to create sustainable solutions for society; systems-based, trans-disciplinary approach to sustainability, problems in sustainability and appropriate solutions based on scientific research, applied science, social and economic issues; life cycle inventory (LCI) and life cycle impact assessment (LCIA) including the social and economic dimensions. The application of life cycle assessment methodology using appropriate case studies

Suggested Books:

1. Hauschild, Rosenbaum, and Olsen, Life Cycle Assessment: Theory and Practice, Spriger Publisher
2. Schenck R and White P, Environmental Life Cycle Assessment: Measuring the environmental performance of products, American Centre for LCA
3. Curran MA, Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products, Wiley-Publishers.

ENE6201 Hazardous Waste Management

Hazardous waste management: Definition and characteristics, Sources and categorization, Treatment technologies: Physico-chemical, thermal, biological, sea and land disposal, Hazardous Waste (Management & Handling) Rules, Basel convention; Waste destruction technologies, Waste concentration technologies, TSDF; cradle to grave approach, Solidification and Stabilization Technologies, Biological Treatment, Storage and Disposal of radioactive waste

Suggested Books:

1. LaGrega, Buckingham, and Evans Hazardous Waste Management, Waveland Pr Inc. 2010
2. Rao MN and Sultana R, Solid and hazardous waste management, Elsevier Publisher 2017

ENE6203 Bioremediation

Basic principles of chemical and biological degradation of toxic chemicals, application of the remedial technologies in natural environments; occurrence and ecological significance of toxic organic chemicals; chemistry of contaminants, kinetics and mechanisms of degradation (chemical and biological); current technologies of bioremediation of contaminated soils and water.

Suggested Books:

1. Alexander M, Biodegradation and bioremediation, Elsevier Publisher 1999
2. Wise D, Bioremediation of Contaminated Soils, CRC Press 2000

Semester IV

ENE652 Research Project

ENE602 Major Project II

DEPARTMENT OF MECHANICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Computational Design)

Programme Specific Outcomes

1. An ability to identify industrial problems and to provide possible solutions with the help of Engineering tools.
2. An ability of collaborative learning to find out sustainable solution for social issues.
3. Apply the knowledge of Engineering to the solution of complex problems through empathy and creativity.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN COMPUTATIONAL DESIGN (CDN)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I														
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	CDN 501	System Modelling, Simulation and Analysis	Core	4	3	0	2	15	25	20	40	-	17
	2	CDN 503	Computati-onal Mechanics of Materials	Core	4	3	0	2	15	25	20	40	-	
Group B	3	CDN 5401/5403/.....	Elective 1	Elective	4	3/4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-	
	4	CDN 5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	CDN 5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	CDN 502	Finite Element Method	Core	4	3	0	2	15	25	20	40	-	17
	2	CDN 504	Robotics and Control	Core	4	3	0	2	15	25	20	40	-	
Group D	3	CDN 5402/5404/.....	Elective 4	Elective	4	3/4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-	
	4	CDN 5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	CDN 5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester III

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group E	Track 1													12
	1	CDN 651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	CDN 601	Major Project I	Core	3						40	60		
	2	CDN 6401/6403/.....	Elective 7	Elective	4	3/4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-	
	3	CDN 6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	CDN 6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester IV

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													12
	1	CDN 652	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	CDN 602	Major Project II	Core	12	0	0	12	0	-	0	100	-	

LIST OF ELECTIVES :

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	CDN5401	Advanced theory of Vibration and Control	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	CDN5403	Fracture Mechanics		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	CDN5405	Theory of Elasticity and Plasticity		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	CDN5301	Optimization Techniques in Design	Elective	3	3	0	0	20	-	30	50	-
	2	CDN5303	Numerical Methods in Engineering		3	3	0	0	20	-	30	50	-
	3	CDN5305	Design of Experiments		3	3	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	CDN5201	Seminar	Elective	2	2	0	0	2	-	-	100	-
	2	CDN5203	Smart Structures and Materials		2	2	0	0	20	-	30	50	-
	3	CDN5205	Human Factors in Engineering and Biomechanical Design		2	2	0	0	20	-	30	50	-
	4	CDN5207	Design for Manufacture		2	2	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	CDN5402	Engineering Tribology and Bearing Design	Elective	4	3/ 4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-
	2	CDN5404	Rapid Prototyping and Tooling		4	3/ 4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-
	3	CDN5406	Innovative Engineering Design		4	3/ 4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	CDN5302	Minor Project	Elective	3	0	0	-	-	40	-	-	60
	2	CDN5304	Rotor Dynamics		3	3	0	0	20	-	30	50	-
	3	CDN5306	Product Design and Development		3	3	0	0	20	-	30	50	-

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	CDN5202	Reliability Engineering	Elective	2	2	0	0	20	-	30	50	-
	2	CDN5204	Product Life Cycle Management		2	2	0	0	20	-	30	50	-
	3	CDN5206	Noise and Acoustics Design		2	2	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	CDN6401	Computational Methods for Fluid Dynamics	Elective	4	3/ 4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-
	2	CDN6403	Machine Tool Design		4	3/ 4	0	2/ 0	15 /20	25/0	20/ 30	40 /50	-
	3	CDN6405	Pressure Vessels and Piping Design		4	3/ 4	0	2/ 0	15 /20	25/0	20 /30	40 /50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	CDN6301	Composite Material Technology	Elective	3	3	0	0	20	-	30	50	-
	2	CDN6303	Mechatronic System Design		3	3	0	0	20	-	30	50	-
	3	CDN6305	Instrumentation and Control Systems		3	3	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	CDN6201	Computer Aided Design	Elective	2	2	0	0	20	-	30	50	-
	2	CDN6203	Surface Engineering		2	2	0	0	20	-	30	50	-
	3	CDN6205	Automotive System Design		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

CDN501 System Modelling Simulation and Analysis

A review of basic probability and statistics; Physical Modelling: Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation; Modeling of Physical System Dynamics: A Unified Approach: Physical systems, Introduction to Bond graphs, Ports, Bonds and Power; Elements of Bond graphs; Derivation of System equations from Bond graphs in first order state space form; Bond Graph Modeling of Multi-energy Systems: Mechanical Systems, Translation and rotation (about a fixed axis); System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Simulation software packages; System Dynamics: Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation; Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems.

Suggested Books:

1. System Simulation by Geoffrey Gordon, Prentice Hall
2. System Simulation: The Art and Science by Robert E. Shannon, Prentice Hall
3. System Modelling and Control by J. Schwarzenbach and K.F. Gill Edward Arnold
4. Modelling and Analysis of Dynamic Systems by Charles M Close and Dean K. Frederick Houghton Mifflin
5. Simulation of Manufacturing by Allan Carrie, John Wiley & Sons
6. Bond Graph in Modeling, Simulation and Fault Identification by Amalendu Mukherjee, Ranjit Karmakar, Arun Samantary , I.K. Int. Pub. house

CDN503 Computational Mechanics of Material

Analysis of deformation and motion: Motion of a continuum, deformation gradient, polar decomposition, objectivity of tensor fields, measures of strain, rate of deformation and vorticity; Transport theorem, balance laws: Mass conservation, momentum balance equations, Cauchy stress tensor, Conjugate stress tensors, stress rates; General constitutive theory: Material symmetry, invariance requirements, Cauchy elastic material, Green elastic material; Analysis of large deformation and strain in 3-D elastic continuum: Formulation of boundary value problems: examples; Variational principles and conservation laws: Virtual work principle for large deformation problems. Principle of stationary potential energy, complementary and mixed variational principles, variational principles with constraints.

Reference Books

1. Continuum Mechanics by Gurtin and Anand
2. Continuum Mechanics by J. N. Reddy
3. Nonlinear elastic deformations by R. W. Ogden

CDN5401 Advanced Theory of Vibration and Control

Single degree of Freedom System; Two-degree of Freedom System: Principal modes of vibration, Vibration isolation; Multi-degree Freedom systems: Eigen-value problem, Close coupled and far coupled systems, Orthogonality of mode shapes, Modal analysis for free, damped and forced vibration systems, Approximate methods for fundamental frequency; Vibration Control: Vibration control strategies and case studies, experimental and theoretical routes to vibration engineering, vibration testing. Application of damping treatment for vibration control in machines and structures; Dynamic Instability Control: Dynamic instability control, Introduction to modal tesing, modal updating and structural dynamic modifications to improve dynamic design of machine structures, Active control of vibrations, Introduction to NVH and its control. Random vibrations, Measurement and processing of random data; Continuous systems; Non-linear Vibrations.

Reference Books:

1. Theory and practice of Mechanical Vibrations by J.S. Rao and K. Gupta, New Age International
2. Mechanical Vibrations by G.K. Groover, Nem Chand & Brothers
3. Mechanical Vibration Practice by V. Ramamurti, Narosa Publications
4. Mechanical Vibrations by V.P. Singh, Dhanpat Rai & sons
5. Textbook of Mechanical Vibrations by R.V. Dukkipati & J. Srinivas, Prentice Hall of India
6. Dynamics of structures by Chopra, Pearson press
7. Vibration and Control by A.K. Mallik

CDN5403 Fracture Mechanics

Fracture mechanics principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. The Airy stress function; Determination of Stress intensity factors and plane strain fracture toughness: Plane strain fracture toughness test, Criteria for crack growth. The crack resistance(R curve). Compliance, J integral. Tearing modulus. Stability. Plasicity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor; Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test; Elastic plastic fracture mechanics : Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD.Parameters affecting the critical CTOD.Use of J integral. Limitation of J integral;

Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness, Testing for fracture; Fatigue crack propagation and applications of fracture mechanics: Use of FEM softwares like ABAQUS for analysis of bodies containing cracks.

Reference Books:

1. Elementary Engineering Fracture Mechanics by David Brock, Noordhoff.
2. Fracture Mechanics-Fundamental and Application by Anderson, T.L CRC press1998.

3. Engineering fracture mechanics by S.A. Meguid, Elsevier.

4. Fracture of Engineering Brittle Materials, Applied Science - Jayatilake, London.

CDN5405 Theory of Elasticity and Plasticity

Introduction: Analysis of stress and strain; Equilibrium; Specification of stress at a point; Elastcity Problems: Airy's stress function, investigation for simple beam problems; Yield Criteria for Materials: Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material. Hills' criterion, Plastic stress-strain relations, Prandtl Reuss Saint Venant, Levy - Von Mises, Experimental verification of the Prandtl-Rouss equation, Yield locus, Symmetry convexity, Normality rule; Upper and lower bound solutions: Upper and lower bound theorems and and corollaries. Application to problems: Uniaxial tension and compression, bending of beams, Torsion of rods and tubes, Simple forms of indentation problems using upper bounds. Slip line theory, Basic equations for incompressible two dimensional flow, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines.

Reference Books:

1. Engineering Plasticity - Theory and Application to Metal Forming Process by R. A. C. Slater, McMillan Press Ltd.

2. Theory of Plasticity and Metal forming Process by Sadhu Singh, Khanna Publishers, Delhi.

3. Plasticity for Mechanical Engineers - Johnson and Mellor.

CDN5301 Optimization Techniques in Design

Introduction to Optimization - Problem Statement, Classification of optimization problems and applications; Classical Optimization techniques: Unconstrained Optimization: Optimizing Single-Variable Functions, conditions for Local Minimum and Maximum, Optimizing Multi- Variable Functions. Constrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Lagrange Multipliers Method. Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary conditions, Kuhn –Tucker Sufficient Conditions; Goal Programming: Formulation and solution of goal problems; Non-Linear Programming: One-Dimensional Methods: Elimination Methods, Interpolation Methods, Direct Root Methods; Quasi-Newton Method, Secant Method. Dichotomous search method, Fibonacci method, Golden section method, Unconstrained Optimization Techniques: Direct search methods, Descent Methods. Constrained Optimizations: Direct and Indirect methods; Dynamic Programming: Concept of Dynamic Programming, Multi stage Decision Process, Calculus Method and Tabular Method; Integer Programming – Branch and bound Method, Cutting Plane Method; Introduction to Advanced Optimization Techniques: Genetic Algorithms (GA), Simulated Annealing, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Neural Network, Separable Programming, Stochastic Programming, Monte Carlo Simulation.

Reference Books:

1. Operations Research by Taha, H . A., PHI

2. Optimization of Engineering Design by Deb, K., PHI

3. Operations Research buy D. S. Hira and P. K. Gupta, S. Chand

4. Optimization techniques by Rao, New Age international

5. Introduction to Optimal Design by Jasbir Singh Arora, McGraw Hill International

CDN5303 Numerical Methods in Engineering

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation; Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss- Seidal), convergence of iteration methods, eigen values and eigen vectors Interpolation methods: Newton's divided difference, interpolation polynomials , Lagrange interpolation polynomials;

Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration; Transform techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, Discrete Fourier Transform (DFT),Fast Fourier Transform(FFT); Differential equations: Initial and boundary value problems, eigenvalues problems, solutions to elliptical and parabolic equations, partial differential equations. Regression methods: Linear and non-linear regression, multiple linear regression, general linear least squares; Statistical methods: Statistical representation of data, modeling and analysis of data, test of hypotheses; Solution to practical engineering problems using software tools

Reference Books:

1. Applied Numerical Methods for Engineering using MatLab and C by Schilling R. J and Harris S L, Brooks/Cole Publishing Co.
2. Numerical Methods for Engineers by Chapra S C and Canale R P, McGraw Hill
3. Probability and Statistics in Engineering and Management Studies by Hines, W.W and Montrogmery, John Willey
4. Numerical Methods for Engineers by Santhosh K.Gupta, New Age international publishers

CDN5305 Design of Experiments

Introduction: Basic principles, Guidelines for designing experiments, history of statistical design, statistical design in experimentation; Simple Comparative Experiments: Basic statistical concepts, Sampling and sampling Distribution, Inferences in means, randomized designs, Paired comparison Designs, Inferences in Normal Distributions; Introduction to Factorial Design: Definition and principles, Advantages of factorials, The two factor factoriai design, General factorial design, Fitting response curves and Surfaces, Blocking in a factorial design; Fitting Regression Models: Linear regression models, Estimate of parameters, Hypothesis testing and Confidence intervals in multiple regression, Prediction of new response observations, Regression model diagnostics, Testing for lack of fit; Taguchi Method: Concept design, Parameter design, Tolerance design, Quality loss function, S/N ratio, Orthogonal array experiments, Analysis of Mean (ANOM), Selection and testing of noise factors, control factors, Parameter optimization experiment, Parameter design case study; Analysis of Variance: Degrees of freedom, Error variance and pooling, Error variance and application, Error variance and utilizing empty columns, the F-test.

Reference Books:

1. Probability and Statistics for Engineers and Scientists by Walpole, Myers, Myers and Ye, Pearson Education.
2. Statistics in Research by Bernand Ostle & Richard N.Mensing, Oxford & IBH Pub Co.
3. Probability and Statistics in Engineering by Hines, Montgomery, Goldsman and Borror, John Wiley & Sons.
4. Experimental Design, Theory & application by Federer, Oxford & IBH pub Co

CDN5203 Smart Structure and Materials

Overview of Smart Materials, Structures and Products Technologies; Smart Materials (Physical Properties) piezoelectric materials, materials, magnetostrictive electrostrictive materials, magnetoelectric materials. magnetorheological fluids, electrorheological fluids, applications of electroreological fluids, shape memory materials, fiber-optic sensors; Smart Sensor, Actuator and Transducer Technologies smart sensors: accelerometers; force sensors; load cells; torque sensors; pressure sensors; microphones; impact hammers; MEMS sensors; NEMS sensors, sensor arrays smart actuators: displacement actuators; force actuators; power actuators; vibration dampers; shakers; fluidic pumps; motors smart transducers: ultrasonic transducers; sonic transducers; air transducers; Measurement, Signal Processing, Drive and Control Techniques quasi-static and dynamic measurement methods; signal-conditioning devices; constant voltage, constant current and pulse drive methods; calibration methods; structural dynamics and identification techniques; passive, semi-active and active control; feedback and feed forward control strategies; Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products.

Reference Books:

1. Smart Materials and Structures by M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York
2. Smart Structures and Materials by B. Culshaw, Artech House, Boston
3. Smart Structures: Analysis and Design by A. V. Srinivasan, Cambridge University Press, Cambridge; New York
4. Electroceramics: Materials, Properties and Applications by A. J. Moulson and J. M. Herbert. John Wiley & Sons
5. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York
6. Piezoelectric Actuators and Wtrasonic Motors by K. Uchino, Kluwer Academic Publishers, Boston
7. Handbook of Giant Magnetostrictive Materials by G. Engdahl, Academic Press, San Diego, Calif.; London
8. Shape Memory Materials by K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York

CDN5205 Human Factors Engineering and Biomechanical Design

Introduction: Human factors and systems. Human factors research methodologies; Information Input: Information Input and Processing, Text, Graphics, Symbols and Code, Visual Display of Dynamic Information, Auditory, Tactual and Olfactory Displays, Speech Communications; Human Output and Control; Physical Work and Manual Materials Handling Motor Skills, Human Control of systems, Controls and Data Entry devices, Hand tools and devices; Workplace Design: Applied Anthropometry, Work-space design and Seating, Arrangement of Components within a Physical Space, Interpersonal Aspects of Workplace Design; Environmental Conditions; Illumination, Climate, Noise, Motion; Human Factors Applications; Human Error, Accidents and Safety, Human Factors and the Automobile. Human Factors in Systems design; Biomechanical Design: Biomechanical systems, Biomechanical analysis, Natural design vs Mechanical Design, Designing and developing equivalent mechanical systems, Case studies and analysis, Biomechanical modeling and simulation.

Reference Books:

1. Human Factors In Engineering and Design by Mark Sanders, Ernest McCormick, McGraw-Hill International Editions.
2. Biomechanics Vol. 1, 2, 3 by Y.C. Fung,

CDN5207 Design for Manufacture

Effect of Materials And Manufacturing Process On Design: Major phases of design. Effect of material properties, Effect of manufacturing processes, Material selection process; Tolerance Analysis: Process capability, mean, varience, skewness ,kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish; Selective Assembly: Interchangeable and selective assembly, Deciding the number of groups -Model-1: Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations; Datum Features: Functional datum, Datum for manufacturing, changing the datum; Design Considerations for Casting; Component Design for Manufacturing; True positional theory: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance; Design of Gauges.

Reference Books:

1. Designing for Manufacturing by Harry Peck, Pitman Publications
2. Machine Design by Dieter McGraw hill Publications for topic 1.
3. Metrology by R.K. Jain Khanna Publication for topic 6.
4. Product design for manufacture and assembly by Geoffrey Boothroyd, peter dewhurst, Winston Knight, Mercel dekker. Inc. New york.
5. Material selection and Design, Vol. 20 by ASM Hand book.

SEMESTER II

CDN502 Finite Element Method

Introduction to Finite Element Method; One-Dimensional Elements-Analysis of Bars and Trusses; Two-Dimsional Elements-Analysis of Plane Elasticity Problems, Axi-symmetric Solid Elements-Analysis of Bodies of Revolution under axi-symmetric loading; Three-Dimensional Elements-Applications to Solid Mechanics Problems; Beam Elements-Analysis of Beams and Frames; Heat Transfer and Fluid Flow; Dynamic problems

Reference Books:

1. Finite Elements in engineering by Chandrupatla T. R., PHI
2. Finite Elements Analysis – Procedures in Engineering by Lakshminarayana H. V., Universities Press
3. Finite Elements Method in Engineering by Rao S. S., Elsevier
4. Textbook of Finite Element Analysis by P. Seshu, PHI

5. Finite Element Method by J.N.Reddy, McGraw -Hill International Edition.

6. Concepts and Application of Finite Elements Analysis by Cook, Malkus, Plesha and Witt, Wiley & Sons

7. Finite Element Method by K. J. Bathe, Prentice Hall of India

8. FEM by Zienkiewicz and Taylor

CDN504 Robotics and Control

Introduction; Evolution of robot and robotics, laws of robotics, robot anatomy: Links, joints, Degrees of freedom (DOF), Arm configuration, wrist configuration, end-effectors; Coordinate Frame, Mapping and Transforms; Coordinate frames, description of objects in space, transformation of vectors, inverting a homogeneous transform, fundamental rotation matrices; Kinematics; Denavit- Hartenberg Notation, kinematic relationship between adjacent links, Manipulator transformation matrix, Inverse kinematics Linear and angular velocity of a rigid body, velocity propagation along links, manipulator jacobian; Dynamics:

Lagrange-Euler Formulation, Newton-Euler Formulation; Control of manipulators: Position control, Force control: Applications of standard control strategies; Actuators:Types, Characteristics, Comparision of hydraulic, Electric, pneumatic, actuators, Hydraulic actuators, Proportional feedback control, Electric Motors; Sensors: Sensor characteristics, Position sensors, Displacement sensor, Velocity sensor-, Acceleration sensors, Force and Pressure sensors, Torque sensors, Touch and tactile sensor, Proximity

Reference Books:

1. Fundamental Concepts and Analysis by Ghosal A., Robotics, Oxford

2. Introduction to Robotics Analysis by Niku, S. B., Systems, Applications, Pearson Education

3. Introduction to Robotics: Mechanica and Control by Craig, J. J., Addison-Welsey

4. Fundamentals of Robotics, Analysis and Control by Schilling R. J., PHI

5. Robotics Control, Sensing, Vision and Intelligence by Fu, K, S., Gonzalez R. C., Lee C.S. G., McGraw Hill

CDN5402 Engineering Tribology and Bearing Design

Introduction: definition, Lubrication, wear, cost of friction and wear.

Friction and Wear: Law, concept, Taylor's model of friction, Measurement of friction.

Laws of wear, Abrasive, Erosive and Cavitation wear, Effect of particle shape, hardness, size and flux rates on erosive wear rate. Erosive wear. Adhesion and adhesive wear: Mechanism of adhesion. Corrosive and oxidative wear: Introduction, corrosive wear, transition between corrosive and adhesive wear, synergism between corrosive and abrasive wear, oxidative wear, kinetics of oxide film growth on metals at high and low temperatures. Fatigue wear: Introduction, fretting wear, melting wear, wear due to electrical discharges, diffusive wear, impact wear. Sitiback number, curve and law. Lubrication: Solid lubrication and surface treatments, Hydrostatic Lubrication, formation of fluid film, pressure distribution and flow, normal load component, frictional torque and power loss, gas lubrication. Thermo hydrodynamic lubrication.

Bearing Design: Design of bearing, Heat generation and cooling or bearing hydrostatic and dynamic and their applications in machine tools. Design of air bearing ad other gas bearing

Reference Books:

1. Engineering Tribology by Gwidon W. Stachowiak and Andrew W. Batchelor
2. Fundamentals of fluid film lubrication by Bernard J. Hamrock
3. Industrial Tribology by Dr. B. S. Prabhu, McGraw Hill

CDN5404 Rapid Prototyping and Tooling

Introduction: Historical developments, Fundamentals of RP Systems and its Classification, Rapid prototyping process chains, 3D modeling and mesh generation, Data conversion and transmission; RP Systems: Liquid polymer based rapid prototyping systems, Teijin Seikis' solid form and other similar commercial RP systems, Solid input materials based rapid prototyping systems, laminated object manufacturing (LOM) and fused deposition modelling systems etc., Power based rapid prototyping systems, selective Laser sintering, Soligen Diren's shell production casting (DSPC), Fraunhofer's multiphase jet solidification (MJS) and MIT's 3D printing (3DP) etc.; RP Database: Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data; RP Applications: Development of dies for moulding, RP applications in developing prototypes of products, application in medical fields, Development of bone replacements and tissues, etc., RP materials and their biological acceptability.

Reference Books:

1. Rapid Prototyping of Digital Systems: A Tutorial Approach by Hamblen James O Kluwer Aca
2. Rapid Prototyping: Principles And Applications by Chua, Leong and Lim, World Scientific
3. Rapid System Prototyping With Fpgas: Accelerating The Design Process by Cofer and Harding, Newnes
4. Rapid Prototyping of Digital Systems by James O Hamblen, Springer

CDN5406 Innovative Engineering Design

Creative Product & System Design: Creative design, Innovation versus invention, Globalisation, Team work, Project Scheduling and management; Creative Mind: Whole Brain thinking, Creativity, What makes an individual creative?; Reclaiming Creativity: Mental Barriers, Types of mental Barriers, False assumptions and nonexistent limitations, Associating thinking, misunderstandings, inability to communicate properly, emotions, culture and environment related barriers, improper method of solution; Creative Problems solving Techniques: Brain storming, 6-3-5 method, Morphological attitude list, list of alternative actions, analogy (Case based reasoning) method, random attributes Scamper method; Imagination, visualisation, graphical representation and communication: Imagination, drawings, engineering drawings, realistic drawings, Perspectives and location of objects, determining depth in perspective: scale factors, drawing perspective, sketching, put in- the-box scheme: Design Consideration and Decisions; Economics of Design: Value of a Product or System, Global Economics Models, Costs, Revenues and Profits, Cost Breakdown of Products and Systems, Product Life Span, Engineering Economy; Design and Product Liability: Standards and Codes.

Reference Book:

1. Creative Design of Products and Systems by Saeed Benjamin Niku,

CDN5304 Rotor Dynamics

Fluid Film Lubrication: Basic theory, Generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, hydrodynamic journal bearing, Two lobe journal bearings; Stability of Flexible Shafts: Introduction, flexible shaft with rigid support. Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation, instability in magnetic field; Critical Speed; Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the centre; Turbo-rotor System Stability by Transfer Matrix Formulation: General turbo-rotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions; Turbo-rotor System Stability by Finite Element Formulation; Blade Vibration: Centrifugal effect, Transfer matrix and Finite element, approaches.

Reference Books:

1. Principles of Lubrication by Cameron Longmans.
2. Nonconservative problems of the Theory of elastic stability by Bolotin, Pergamon.
3. Matrix methods of Elastomechanics by Peztel, Lockie, McGraw Hill.
4. Vibration Problems in Engineering by Timosenko, Young, Von Nostrand 5. Zienkiewicz, "The Finite Element Method", McGraw Hill.
5. Rotor Dynamics by J. S. Rao
6. Rotor Dynamics by Tondel

CDN5306 Product Design and Development

Stages in design process: Introduction to various stages of the design process: Formulation of problem, Generation of alternatives, Evaluation, Guided Redesign. Case study; Product life cycle:

New product introduction: early introduction, increased product life. Life cycle management tools: System integration, QFD, House of quality, Pugh's method, Pahl and Beitz method. Case studies; Value engineering: Introduction, nature and measurement of value. Value analysis job plan. Creativity and techniques of creativity. Value analysis test. Case studies: Concurrent/ reverse engineering: Introduction, basic principles, components, benefits of concurrent engineering. Concept of reverse engineering; Material selection; Process selection: Introduction. Process classification: shaping, joining and finishing. Systematic process selection. Ranking, process cost. Computer – aided process selection; Design for manufacture and assembly; Design for "X"; Introduction. Design for: Safety, packaging and storage, quality, reliability, energy conservation, environment, aesthetics, ergonomics, maintenance, recyclability and disposal. Case studies; Patents, liability and ethics.

Reference Books:

1. Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, Mc GrawHill
2. Integrated Product and Process Development by John M. Usher, Utpal Roy and H. R. Parasaei
3. Product Design for Manufacture and Assembly by G. Boothroyd, P. Dewhurst and W. Knight, Marcel Daker
4. Engineering Design and Design for Manufacturing: A structured approach by John R. Dixon and Corrodo Poli, Field Stone Publishers, USA.
5. Material Selection in Mechanical Design by M. F. Ashby, Elsevier.

CDN5202 Reliability Engineering

Introduction: System concepts in reliability, availability and maintainability (RAM) Engineering, Practical applications of RAM Engineering to systems, products and processes; Concepts, terms and definitions; Failure rate function, Probability density function, Cumulative distribution function, reliability function, Mean time to failure (MTTF), MTBF, MTTR etc.; Fundamentals of reliability:

Failure distributions; Exponential, Weibull, Normal and Lognormal; Constant failure rate model and time dependent failure models; System reliability assessment: Series, Parallel, Combined series-parallel configurations; Cut sets and path sets approach, fault tree analysis (FTA); State dependent systems; Markov analysis, load sharing system, standby system, degraded system, Monte Carlo simulation; Design for Reliability and reliability improvement: Reliability specifications and system measurements, reliability allocation ; exponential case, optimal allocations, arnica method, AGREE method, Various types of redundancies; active and passive redundancy, k-out-of-n- redundancy, standby redundancy, optimization , reliability-cost trade off; Availability and maintainability; Design for maintainability.

Reference Books:

1. An introduction to Reliability and Maintainability Engineering by Ebeling Charies E., Tata McGraw-Hill
2. Reliability Engineering by Srinath, L. S., East –West Press Ltd.
3. Engineering Maintainbility by Dhillon, B. S., Prentice Hall of India
4. Logistics Engineering and Management by Blanchard, Benjamin, S., Prentice Hall of India

CDN5204 Product Life Cycle Management

Introduction: Extensive definition of Concurrent Engineering (CE), CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA (Design for assembly), QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, Organizing for CE, CE tool box, Collaborative product development; Use of Information Technology: IT support, Solid modeling, Product data management, Collaborative product Commerce, Artificial Intelligence, expert systems, Software hardware component design; Design Stage: Lifecycle design of products, Opportunities for manufacturing enterprises, Modality of concurrent engineering design, automated analysis Idealization control, CE in optimal structural design, Real time constraints; Need for PLM; Components of PLM: Components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, Practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards.

Reference Books:

1. Integrated Product Development by M. M. Anderson and L Hein, IFS Publications
2. Design for Concurrent Engineering by J. Cleetus, CE Research Centre, Morgantown
3. Concurrent Engineering Fundamentals: Integrated Product Development by Prasad, Prentice hall India
4. Concurrent Engineering in Product Design and Development by I Moustapha, New Age International
5. Product Lifecycle Management by John Stark, Springer-Verlag, UK

6. Product Lifecycle Management by Michael Grieves, McGraw Hill

7. Concurrent Engineering: Automation tools and Technology by Andrew Kusiak, Wiley Eastern

CDN5206 Noise and Acoustic Design

Mathematical Basis of Acoustics; Radiation and Reception of Acoustics Waves; Pipes Resonators and Filters: Noise, Signal detection, Hearing and speech; Architectural Acoustics:

Environmental Acoustics; Measurement of Sound and Vibration; Noise Pollution

Reference Books:

1. Fundamentals of Acoustics by Lawerence E.Kinsler, Austin, R.Frey, Alan B.Coppens, James V.Sanders, Wiley

2. Acoustics by L. Berarek, McGraw-Hill

SEMESTER III

CDN6401 Computational Methods for Fluid Dynamics

Introduction: Conservation equation, Mass Momentum and Energy equations, Convective form of the equation and general description; Clarification into various types of equation: Parabolic, Elliptic, Boundary and initial conditions, Overview of numerical methods; Finite difference methods: Different means for formulating finite difference equations, Taylor series expansion, Integration over element, Local function method; Finite volume methods; Central, upwind and hybrid formulations and comparison for convection-diffusion problem, Treatment of boundary conditions; Boundary layer treatment; Variable property, Interface and free surface treatment, Accuracy of F.D. method; Solution of finite difference equations; Iterative methods; Matrix inversion methods, ADI method, Operator splitting, Fast Fourier Transform applications; Phase change problems, Rayleigh-Ritz, Galerkin and Least square methods; Interpolation functions, One and two dimensional elements, Applications. Phase change problems; Different approaches for moving boundary; Variable time step method, Enthalpy method.

Reference Books:

1. Computational Methods for Fluid Dynamics by Ferziger Joel H, Springer-Verlog

2. Principles of Heat Transfer by Kaviany M, Wiley-International

3. Radiative Heat Transfer by Modest Michael, Academic Press

CDN6403 Machine Tool Design

Design approach: Design requirements of machine tools. A design approach for machine tools. Identification and quantification of objectives and constraints in machine tool design. Kinematics of machine tool drives, stepped and stepless speed regulation; Power requirements: Estimation of power requirements and selection of motor for metal cutting machine tool spindles: 1. Gearbox design, 2. Design of gearbox, spindle and guide-ways;

Structural design: Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and over arms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements; CNC machine design: Introduction to computer integrated manufacturing systems and CNC machine tools; Design of CNC systems.

Reference Books:

1. Design of Devices and Systems by William H. Middendorf and Richard H. Engelmann, CRC Press.
2. Computer numerical control of machine tools by G. E. Thyer, Heinemann Professional Publishing.
3. Machine Design Fundamentals: A Mechanical Designers' Workbook by Joseph Edward Shigley and Charles R. Mischke, Mcgraw Hill.
4. Numerical Control and Computer aided manufacture by Kundra, Rao, Tiwari, Tata McGraw Hill.

CDN6405 Pressure Vessels and Piping Design

Stresses in pressure vessels: Membrane stresses, dilation of pressure vessels, thick cylinder and thick sphere, bending of plate, discontinuity stresses in pressure vessels, thermal stresses;

Factors influencing the design of pressure vessels: Design criterion of elliptical, hemispherical, conical, toriconical and torispherical heads, Autofrettage; Design of pressure vessel components such as shells, heads, nozzles, flanges as per ASME and IS codes: Localised stresses, stress concentration about a circular and an elliptical opening, theory of reinforced openings, nozzle reinforcement, welded joints; Fracture Control: Fatigue of various components of pressure vessels, Fatigue life prediction, thermal stress fatigue, criteria for design with defects; Piping elements, Dynamic analysis of piping; Use of FEM softwares for stress calculations.

Reference Book:

1. Pressure vessel design by Harvey

CDN6301 Composite Material Technology

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction; Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for twodimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems; Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems; Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems; Macro Mechanical Analysis of Laminate: Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems; Manufacturing; Application Developments; Metal Matrix Composites.

Reference Books:

1. Composite Materials handbook by Mein Schwartz, McGraw Hill Book Company
2. Mechanics of composite materials by Autar K. Kaw, CRC Press New York.
3. Mechanics of Composite Materials by Rober M. Joness, Mc-Graw Hill Kogakusha Ltd.
4. Stress analysis of fiber Reinforced Composite Materials by Michael W, Hyer, Mc-Graw Hill International.
5. Composite Material Science and Engineering by Krishan K. Chawla, Springer.
6. Fibre Reinforced Composites by P. C. Mallik, Marcel Decker.

CDN6303 Mechatronic System Design

Introduction: Definition and Introduction to Mechatronic Systems; Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. Interfacing, ADC, DAC, software and hardware principles and tools to build mechatronic systems; Electrical Actuation Systems: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. Design and selection of mechatronic elements namely sensors like encoders and resolvers. Stepper and servomotors. Ball screws, solenoid like actuators, and controllers; System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydromechanical systems, pneumatic systems; Signal Conditioning: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals , Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation; MEMS and Microsystems; Data Presentation Systems; Advanced Applications in Mechatronics.

Reference Books:

1. Mechatronics by W. Bolton, Addison Wesley Longman, Pub
2. MEMS and Microsystems design and manufacture by HSU, TMH
3. Understanding Electro-Mechanical Engineering by Kamm
4. Mechatronics System Design by Shetty and Kolk, Thomson.
5. Mechatronics by Mahalik, TMH.
6. Mechatronics by HMT, TMH.

CDN6305 Instrumentation and Control Systems

Introduction: Classification and representation of control systems Examples of control systems, closed loop and open loop control systems, The Laplace transform; Mathematical Modelling of Dynamic systems: Transfer function and impulse response function, block diagrams, signal flow graph, statespace representation, Transient response analysis of first order and second order systems; Time domain analysis and design: Root locus method, Routh stability criteria, effect of poles and zeros on system performance; Frequency domain analysis and design:Bode plot , Nyquist stability criteria, Lag , lead compensation; Modern Control Theory: Modern control theory. Sequence control and programmable logic controllers. Control components. Comparators, hydraulic, pneumatic and electrical type of controllers, servomotors; Electromechanical and electro-optical transducers and control elements. Signal conditioning, indicating and recording elements; Computer based systems:

Computer based data acquisition systems, ADC, DAC. Microprocessor applications in measurement and control. Static and dynamic analysis. FFT analysers; Analysis and design:

Controllability and observability, pole placement method, examples of control system design using MATLAB, Current developments in measurement and control of motion, force, torque, pressure, temperature, flow, noise etc. Virtual instrumentation.

Reference Books:

1. Modern Control E ngineering by K. Ogata, PHI.
2. Automatic Control Systems by B.C. Kuo, PHI.

3. Control System Engineering by Nise, Wiley.

4. Modern Control Systems by Dorf and Bishop, Pearson Education.

5. Modern Control System Theory by M. Gopal, New Age International

CDN6201 Computer Aided Design

Introduction and Review of CAD: Introduction and Overview, Need and Scope of computer aided Machine design, Role of Geometric modelling, Principles of interactive Computer graphics, Overview of hardware available for use in CAD; Three Dimensional Transformations: Geometric transformations & Axonometric, Diametric, Trimetric and oblique Projections, Windowing & View porting; Geometric Modelling and Applications: Introduction, wire frame models and entities, curve representations, parametric representation of analytical curves, synthetic curves, Bezier curves, B-spline curves, Rational curves, curve manipulations, design and engineering applications; Solid modelling: Half spaces, Boundary representation (B-rep), Constructive solid geometry (CSG), Sweep representation, Analytical solid making, and solid manipulation; Advances in Computer Aided Engineering Design: Failure considerations in designing, Robust design, Reliability, Ergonomic considerations in Design, Feature based design, Design for manufacturing, Design for Automation, CAD of complex Engg. Systems.

Reference Books:

1. Computer Graphics by D Hearn & M P Baker, Prentice Hall

2. CAD/CAM Theory and Practice by Ibrahim Zeid & R Sivasubramanian, Tata McGraw- Hill

3. CAD/CAM- Principles and Applications by P N Rao, Tata McGraw-Hill

4. Computer Aided Engineering Design by A Saxena and B Sahay, Anamya Publications

5. Mathematical Elements for Comp. Graphics by D F Rogers and J A Adams, McGraw-Hill International

6. CAD/CAM by H P Groover and E W Zimmers, Prentice Hall

7. Computer Graphics and Design by Radhakrishnan and Kothandaraman, Dhanpat Rai

8. Procedures Elements for Computer Graphics by Rogers David F, Tata McGraw Hill

CDN6203 Surface Engineering

Introduction- thermal spray coating. Definition, History, Coating Build-up, Market segmentation, Material used for spraying, Method of powders production, Methods of powder characterization, Spray drying, Cladding, Mechanical alloying, Self propagating high temperature synthesis; Pre-spray treatment: Introduction, Surface cleaning, Substrate shaping, Surface activation, Masking, Thermal spraying techniques; Thermal spray process: Introduction, Flame spraying, Atmospheric plasma spraying, Arc spraying, Detonation gun spraying, High velocity oxy fuel spraying, Vacuum plasma spraying; Post spray treatment: Heat treatment, Impregnation, Finishing, Method of coating characterization, Method of microstructure characterization, Mechanical properties of coating, Physical properties of coating, Chemical properties of coating; Properties of coatings: Mechanical properties, Thermo-physical properties, Electric properties, Magnetic properties, Optical properties, Corrosion resistance, Application of coatings: Corrosion protection, Iron and steel industries, Energy generation and transport, Non ferrous metal industries, Paper industries.

Reference Books:

1. Introduction to surface engineering and functionally engineered materials by Peter Martin, John Wiley and Sons
2. Tribology and Surface Engineering by J. Paulo Davum, Nova Science Publishing.
3. Advances in Surface Engineering, SA
4. Material and Surface Engineering in Tribology by Jamal Takadoum, Wiley

CDN6205 Automotive System Design

Introduction: Design Requirement of Automobile (power-speed curves), Engine as a system and its subsystems, Fuel injection systems, Cooling system; Design of Various subsystems: Design requirements of the automobile transmission, Automatic transmissions, Dynamic considerations in designing of suspension system, modern systems of suspensions, Kinematic requirements of a steering mechanism, Need for power steering, Braking requirements of an automobile, brake materials; Modeling and simulation: Modeling and simulation of different subsystems, e.g., suspension system, Wheels, Braking system etc.; Instrumentation and control: gauges(speedometer, oil, temperature indicators etc.), microprocessor controlled units, safety and comfort aspects in the automotive component designs; Computer application in automotive Design: Use of softwares like Adams, Abaqus etc to analyse subsystems like transmission system, suspension mechanism and steering mechanism etc.;

Crash modeling of vehicles.

Reference Books:

1. Light and Heavy Vehicle Technology by M J Nunney, Elsevier Butterworth Heinemann
2. An Introduction to Modern Vehicle Design by Jullian Happian Smith, SAE
3. Crashworthiness of Vehicles by Johnson W. and Mamalis AG, MEP London

Semester IV

CDN652 Research Project

CDN602 Major Project II

DEPARTMENT OF MECHANICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Production Engineering)

Programme Specific Outcomes

1. An ability to identify industrial problems and to provide possible solutions with the help of Engineering tools.
2. An ability of collaborative learning to find out sustainable solution for social issues.
3. Apply the knowledge of Engineering to the solution of complex problems through empathy and creativity.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN PRODUCTION ENGINEERING (PRD)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I														
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	PRD501	Theory of Metal Cutting	Core	4	3	0	2	15	25	20	40	-	17
	2	PRD503	Welding Processes & Metallurgy	Core	4	3	0	2	15	25	20	40	-	
Group B	3	PRD5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	PRD5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	PRD5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester II

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	PRD502	Plasticity & Metal Forming	Core	4	3	0	2	15	25	20	40	-	17
	2	PRD504	Casting Technology	Core	4	3	0	2	15	25	20	40	-	
Group D	3	PRD5402/5404/.....	Elective 4	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	4	PRD5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	PRD5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester III

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group E	Track 1													12
	1	PRD651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	PRD601	Major Project I	Core	3						40	60		
	2	PRD6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	3	PRD6301/6303/.....	Elective 8	Elective	3	3	0	0	20	0	30	50	-	
	4	PRD6201/6203/.....	Elective 9	Elective	2	2	0	0	20	0	30	50	-	

Semester IV

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													12
	1	PRD652	Research Project	Core	12	0	0	12	0	-	0	100		
	Track 2													
	1	PRD602	Major Project II	Core	12	0	0	12	0	-	0	100	-	

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	PRD5401	Computer Aided Design / Computer Aided Manufacturing	Elective	4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	2	PRD5403	Computer Integrated Manufacturing Systems		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	3	PRD5405	Mechatronics		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	PRD5301	Principles of Machine Tools	Elective	3	3	0	0	20	-	30	50	-
	2	PRD5303	Automation in Manufacturing		3	3	0	0	20	-	30	50	-
	3	PRD5305	Process Engineering		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	PRD5201	Seminar	Elective	2	2	0	0	2	-	-	100	-
	2	PRD5203	Operation Research		2	2	0	0	20	-	30	50	-
	3	PRD5205	Optimization Techniques		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	PRD5402	Metrology	Elective	4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	2	PRD5404	Methods Engineering and Ergonomics		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	3	PRD5406	Composite Materials and Processing		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	PRD5302	Minor Project	Elective	3	0	0	-	-	-	40	60	-
	2	PRD5304	Maintenance Management		3	3	0	0	20	-	30	50	-
	3	PRD5306	Managerial Concept & Organizational Behaviour		3	3	0	0	20	-	30	50	-

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	PRD5202	Industrial Quality Control	Elective	2	2	0	0	20	-	30	50	-
	2	PRD5204	Supply Chain Management		2	2	0	0	20	-	30	50	-
	3	PRD5206	Production & Operation Management		2	2	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	PRD6401	Advanced Machining Processes	Elective	4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	2	PRD6403	Precision Engineering		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	3	PRD6405	Surface Engineering		4	3 /4	0	2 /0	15 /20	25/0	20 /30	40 /50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	PRD6301	Robotics	Elective	3	3	0	0	20	-	30	50	-
	2	PRD6303	Design for Manufacturing and Assembly		3	3	0	0	20	-	30	50	-
	3	PRD6305	Reliability Engineering		3	3	0	0	20	-	30	50	-
	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	PRD6201	IT in manufacturing Enterprise	Elective	2	2	0	0	20	-	30	50	-
	2	PRD6203	Materials Management		2	2	0	0	20	-	30	50	-
	3	PRD6205	Project Management		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

PRD501 Theory of Metal Cutting

Mechanics of single point and multipoint cutting and abrasive metal removal processes, cutting forces, analysis of work tool system as influenced by tool and work materials, tool geometry and environmental and process variables, Heat transfer and temperature distribution, cutting fluids, Mechanics of tool wear, Tool life, Economics of metal removal, surface finish and dimensional accuracy. Tool Design, Tool design consideration, Selection of tool materials, Tooling economics and safety as related to tool design. Design of Single point cutting tools, Design of Carbide and Ceramic tipped tools, Design of Chip breakers. Design of Multi point cutting tools, Design of Broaches, Twist drill, Reamers and Milling cutters.

Suggested Books:

1. Metal cutting principles by M C Shaw, Oxford University press
2. *Metal cutting* Theory and practice *by A Bhattacharya,* New Central Book Agency
3. Fundamentals of Metal Cutting and Machine Tools by B.L. Juneja, Nitin Seth, G.S. Sekhon, New Age Publishers

PRD503 Welding Process & Metallurgy

Arc, gas and resistance welding processes oxy-acetelyne and arc cutting of metals. Review of modern welding and cutting methods. Welding metallurgy, Heat and temperature during fusion welding, filler metal and metal transfer. Weldability of plain carbon, low alloy, austenitic and other nikel crome steels, Problems and procedure for welding non-ferrous alloys: electrode selection: Design of welded joints, Distortion, residual stresses and stress relieving. Weld defects, Non destructive testing.

Suggested Books:

1. Principles of Welding Technology by L.M. Gourd ELBS/ Edward Arnold
2. Welding processes & technology by Dr. R.S.Parmar, Khanna Publishers

PRD5401 Computer Aided Design / Computer Aided Manufacturing

Introduction to CAD/CAM, representation of curves, surfaces and solids for CAD/CAM applications, computational geometry for manufacturing, product design for manufacture and assembly, computer aided process planning, computer aided assembly planning, computer aided inspection & reverse engineering, manufacturing process simulation, virtual & distributed manufacturing, computer integrated manufacturing

Suggested Books:

1. CAD/CAM by Grover/Zhimmer, PHI
2. Computer Aided Manufacturing by Kundra, Rao, Tiwari , Tata McGraw HILL.
3. CAD/CAM by A J Medland and Piers Buounett, Springer

PRD5403 Computer Integrated Manufacturing Systems

Evolving manufacturing environment, New competitive challenges, Evolving Role Information Technology, CIM Systems: Flexibility, Integration and Automation Opportunities, Automation of information and manufacturing systems, Automation strategies, Towards Flexible Automation, Islands of automation, Evolution Towards CIM systems, Computer based integration between various functions - manufacturing, sales, design, materials etc Flexible Manufacturing Systems (FMS) as mini CIM, Computer Integrated Production Management, ERP, Group technology, Concurrent Engineering, Simulation and AI in CIM systems, CIM and Beyond.

Suggested Books:

1. CAD/CAM by Grover, Zhimmer, PHI
2. Computer Aided Manufacturing by Kundra, Rao, Tiwari , Tata McGraw HILL.
3. Optimization by Joshi and Moudgalya, Narosa
4. CAD/CAM by A J Medland and Piers Buounett, Springer

PRD5405 Mechatronics

Introduction to Mechatronic systems and components; Sensors and transducers; Actuators- electrical, electromechanical, electromagnetic, hydraulic, pneumatic, smart material actuators, micro actuators, nano actuators. Active actuators- piezoelectric, shape memory alloys(SMA), electro active polymers(EAP), magneto restrictive, magneto rheological fluid (MR); Stepper and servo motors, Encoders and resolvers; Modeling, analysis and simulation of dynamic systems; use of MATLAB; Bode, Nyquist and root-locus plot; Feedback systems: Open and closed loop control systems; Stability and sensitivity; PID, phase lag and phase lead compensation; Sampled data systems and Digital controllers; DA/AD converters, microprocessors, interfacing with computers; Digital logic: Analysis and synthesis of echatronic systems with application to robotics, CNC systems and others

Suggested Books:

1. Introduction to Mechatronics and Measurement systems by Alciatore David G., Tata-McGraw Hill India Ltd,
2. Mechatronics: Principles, Concepts and applications by Mahalik.N, Tata-McGraw Hill India Ltd.
3. Mechatronics: Principles and applications by Onwubolu, Elsevier India Pvt Ltd.
4. Mechatronics by W. Bolton, Pearson Education

PRD5301 Principles of Machine Tools

Kinematics of machine tool drives, stepped and stepless speed regulation, design of speed gear box, Design of beds, columns, slides etc., their strength and rigidity, design of spindles and bearings, Automatic and numerically controlled machine tools, Hydraulic drives testing of machine tools. Dynamics acceptance tests, Damping in machine tools, Modern trends in machine tool design, transfer machines.

Suggested Books:

1. Principles of Machine Tools by G.C.Sen and A. Bhattacharya, Central Publication
2. Fundamentals of Machining and Machine Tools by G Boothroyd, McGraw-Hill.

PRD5303 Automation in Manufacturing

Modern developments in automation in manufacturing and its effect on global competitiveness, Need and implications of automation in Manufacturing, different types of production systems and automation, hard/fixed automation. Hydraulic and pneumatic actuators, their design and control devices, sequence operation of hydraulic/pneumatic actuators, designing of systems with hydraulic/ pneumatic, Electro Pneumatic & Electro Hydraulic Systems design, Relay Logic circuits, material handling systems, applications in manufacturing.

Suggested Books:

1. Hydraulic and Pneumatic Controls by Srinivasan R., Vijay Nicole imprints Pvt. Ltd., Chennai.
2. Introduction to Hydraulic and Pneumatic by Ilango S and Soundararajan V., Prentice-Hall of India, Delhi
3. Pneumatic Systems: Principles and Maintenance by Majumdar S.R., Tata McGraw-Hill, Delhi
4. Fluid Power with Applications by Esposito Anthony, Prentice Hall,

PRD5305 Process Engineering

Understanding relation between geometry, materials and manufacturing in relation to process planning. Design for Manufacture and Assembly, Product life-cycle considerations, Selection of raw material geometries, process selection, selection of manufacturing equipment, process sequencing, tooling, work holding and In-process inspection. Process Planning for Assembly & Inspection, Computer Aided Process Planning, Lean concepts in manufacturing.

Suggested Books:

1. Introduction to Process Engineering and Design by Shuchen B. Thakore and Bharat I. Bhatt, McGraw-Hill
2. Manufacturing Engineering Processes by Leo Alting, CRC Press
3. Manufacturing Processes and system by Phillip F Ostwald, Wiley
4. Fundamentals of modern Manufacturing by Mikell P Groover, Wiley

PRD5203 Operation Research

Historical development, Nature of O.R. projects, Model Building Linear deterministic optimization models-linear Programming, Simplex Algorithm, Duality, Degeneracy, assignments, transportation and Trans-shipment models, post optimality analysis. Integer LP., Queing theory, elementary concepts of Dynamics Programming, and Inventory control. Game Theory and Markov Chains. Application of OR software's.

Suggested Books:

1. Operation Research by J. K. Sharma; Macmillan
2. Operations Research by Hamdi A. Taha, Pearson
3. Operations Research: Concepts and cases by F S Hiller and G J Liebermaan, TMH

PRD5205 Optimization Techniques

Introduction to Optimization; Introduction, Engineering Applications, Statement of an Optimization Problem, Classification; Linear Programming : Simplex Algorithm; Two Phase Method, Big 'M' Method, Revised Simplex Method, Duality in Linear Programming; Prime-Dual Relations, Duality Theorem, Dual simplex method, Sensitivity and Post Optimality Analysis. Transportation and Assignment Problem; Integer Programming – Branch and bound Method, Cutting Plane Method; Dynamic Programming: Elementary Concepts of Dynamics Programming, Multi stage Decision Process, Calculus Method and Tabular Method; Classical Optimization techniques – Unconstrained Optimization: Optimizing Single-Variable Functions, Optimizing Multi-Variable Functions. Constrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Lagrange Multipliers Method. Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary conditions, Kuhn –Tucker Sufficient Conditions; Non-Linear Programming-Unconstrained Optimization Techniques: Direct search methods, Descent Methods. Constrained Optimizations: Direct and Indirect methods;Introduction to Advanced Optimization Techniques –Genetic Algorithms (GA), Simulated Annealing, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) etc.

Suggested Books:

1. Optimization of Engineering Design by Deb, K., PHI
2. Operations Research by Hamdi A. Taha, Pearson
3. Operations Research by D.S. Hira, P. K. Gupta, S. Chand
4. Engineering Optimization by S S Rao, New Age international
5. Optimization Techniques by Chander Mohan, Kusum Deep, New Age International

SEMESTER II

PRD502 Plasticity and Metal Forming

Nature of plastic deformation, yield criteria, stress-strain relations in elastic plastic problems, work hardening, formulation of elastic plastic problems. Methods of analysis, slab method, slip line and extremum principles, Application to metal working operations like wire drawing, extrusion, rolling forging, spinning, sheet metal forming etc., study of metal flow, lubrication and wear in forming processes, formability, design of dies, high energy rate forming.

Suggested Books:

1. Fundamentals of Metal forming process by Juneja B.L., New age international Publishers
2. Principal of Industrial Metal working Processes by Rowe G.W, CBS publishers & Distributers
3. Manufacturing Science by Ghosh Amitabha & Mallik Kumar Asok, East-West Prem Pvt Ltd

PRD504 Casting Technology

Casting Processes, Classification, Characteristics of sand-casting processes, metal mould casting processes and casting processes using other mould/core materials, Characteristics and selection of molding sand; Bonding Theory. Solidification of castings, casting design considerations, gating system design, riser design, nucleation and grain growth, solidification of pure metals, short and long freezing range alloys. Rate of solidification, macrostructure and microstructure. Solidification contraction; Mould-metal interface reactions. Cast metals and alloys, Specific considerations to Grey

CI, steel and non ferrous foundry practices. Inoculation and gas removal methods. Casting defects; their causes and their removal, inspection of castings. Quality control in foundries Metal matrix composites and their properties and suitability as casting materials. Special casting processes. Foundry mechanization pollution control in foundries, recent developments.

Suggested Books:

1. Foundry Engineering by Taylor H.F., M.C.Flemings and J.Wulff., John Wiley
2. Foundry Technology by Beely P.R. Butterworths, London
3. Principles of metal castings by Heine R.W., C.R. Loper and P.C Rosenthal, Mc Graw-Hill
4. Castings by Campbell. J, Butterworth-Heinemann, London
5. The science of Engineering Materials by Srinivasan N.K and Ramakrishanan S.J., Oxford and IBH Pub. Co, New Delhi

PRD5402 Metrology

Introduction to dimensional metrology, limits, fits and tolerances, application of tolerances, limit gauging, design of gauges, measuring instruments, comparators and their design considerations, angular measurements, auto collimators and interferometers. applications of dimensional inspection, measurement of screw threads, thread gauges for internal and external threads, gear inspection, inspection of surface quality, parameters for assessing surface finish and experimental methods of surface finish measurements, feature inspection, straightness, flatness, parallelism, squareness, circularity and roundness, automated dimensional measurements, automatic gauging, automatic measuring machines for inspecting multiple workpiece dimensions, measurement with coordinate measuring machines.

Suggested Books:

1. Fundamentals of Mechanical Inspection by R. Jenkins, McGraw Hill.
2. Fundamentals of Dimensional Metrology by C. Dotson, Cengage Learning
3. Engineering Metrology by I.C. Gupta, Dhanpat Rai Publications,
4. Engineering Metrology by R.K. Jain, Khanna Publishers,

PRD5404 Methods Engineering and Ergonomics

Definition, origin, scope and goals of ergonomics as a field of study. Examples of applications of ergonomics in design. Types of data from human at physical, physiological, cognitive and affective levels. Data gathering and analysis techniques. Use of descriptive and inferential statistics in ergonomic data. Applications of mean, median, mode and percentile in anthropometry. Use of anthropometry in workstation design. Human physiological potentials and limitations in terms of load carrying capacity. Concept of comfort, fatigue and stress. Design for the cognitive user. Concept of mental workload. Cognitive perspective in control panel design and graphical user interface design.

Suggested Books:

1. Motion and time study by Ralph M. Barnes, Wiley
2. Motion and time study by Benjamin W. Niebel, Richard D. Irwin, Inc.
3. Operations Research, by D.S. Hira, P. K. Gupta, S. Chand

4. Introduction to Ergonomics by Robert Bridger, CRC Press

5. Indusrial engineering and ergonomics: vision, concepts, methods and tools by Holger Luczak, Springer

PRD5406 Composite Materials and Processing

FRP composites – Fiber types, fiber forms and properties, matrices type and properties, lamina, laminate, orthotrophy, anisotrophy, composites. Macro and micro-mechanical analysis and properties, Failure theories; Tsai – Hill, Tsai-Wu Primary and secondary manufacturing of composites; Lay-up, Autoclave Molding filament Winding, Pultrusion, Compression Molding, RTM, RIM, SRIM, machining, drilling and routing Metal matrix composites; Manufacturing route Design, Structural and testing, application Ceramic matrix composites; Manufacturing routes and application.

Suggested Books:

1. Mechanics of composite materials by Autar K. Kaw, CRC Press, New York

2. Mechanics of Composite Materials by Rober M. Joness, Mc-Graw Hill, Kogakusha Ltd.

3. Stress analysis of fiber Reinforced Composite Materials by Michael W, Hyer,Mc-Graw Hill International

4. Composite Material Science and Engineering by Krishan K. Chawla, Springer

PRD5304 Maintenance Management

Introduction to maintenance management, Reliability basics,Asset criticality Analysis, Reliability centered maintenance, Basic maintenance models for age and time based replacement, block and group replacement, inspection and shock based replacement, imperfect maintenance models, Maintainability models, Availability models, Life cycle cost models, Simulation based approach for maintenance planning, Queuing models for maintenance planning, Models for condition monitoring, Models for Maintenance scheduling, Maintenance performance measurement, Asset management practices, Case studies.

Suggested Books:

1. Engineering Maintainbility by Dhillon,B.S., Prentice Hall of India, New Delhi

2. Logistics Engineering and Management by Blanchard, Benjamin, S., Pearson

PRD5306 Managerial concepts & organizational behavior

The over-all concepts of the nature of management, emergence of management: new challenges; the dimensions of management, the functions of Manager, overview of the functional approach to management-planning, organizing, directing co-ordinating and controlling. Planning, policies, procedure and methods, decision-making. Organising :Organisation structure, principles and theories in orgnisation, departmentalization, vertical and horizontal growth in orgnisation, span of management, centralization and decentralization line and staff function, organisation as a social system-formal and informal organisation. Directing: Administrative communication, motivation and leadership. Delegation. Coordinating: Internal and external coordination, committee in management. Controlling: The process of control, techniques of control Philosophical considerations: Social responsibilities of management, Indian management : the power and influence of Indian management, the role of management associations. Influence of Social and Cultural factors in human behavior. Socio-metry, attitudes, values and norms and factors influencing manager's behavior.

Suggested Books:

1. Management & organizational behaviour by R B Rudani, Tata McGraw-Hill Education.
2. Organizational behaviour by Robbins S P, Judge T A and Sanghi S, Pearson
3. Organizational behaviour by Robbins S P, Pearson

PRD5202 Industrial quality control

Introduction: Quality basics and history, Quality Philosophy (Deming, Juran, Crosby), Dimensions of quality, Quality Costs: Quality Cost Measurement, Utilizing Quality Costs for Decision-Making. Seven QC Tools: Histogram, Pareto Diagrams, Check Sheet, Cause-Effect Diagrams, Scatter Diagrams, Control Charts and Stratification. Statistical Process Control: Control Charts for Variables; Definitions, Variation: Common vs. Special Causes, Control Chart Techniques, X-bar and R chart, X-bar and S charts, Control Chart Interpretation and Analysis, Process Capability, Other Variable Control Charts; Individuals and Moving Range Charts, Moving Average and Moving Range Charts; Control Charts for Attributes: Definitions, Control Charts for Non-conforming Units, Control Charts for Counts of Non-conforming Units; Sampling Techniques: Single, Double, Multiple, Sequential Sampling Techniques, LTPD, AQL, AOQL; Quality Systems: ISO 9000, ISO 14000, ISO 18000, Six Sigma, Certification Requirements, Evolving Standards; Reliability: System concepts in reliability, availability and maintainability (RAM) Engineering, Fundamentals of reliability, Failure distributions, System reliability assessment. Reliability of repairable by Markov approach. Point, mission and steady state availability. Availability assessment. Maintainability and its assessment; Advanced Topics: Quality Function Deployment, Design of Experiments, Benchmarking and Auditing.

Suggested Books:

1. The Management and Control of Quality by J R Evans and W M , Lindsay, Cengage learning, India
2. Total Quality Management by Besterfield, Pearson Education.
3. Statistical Quality Control by Douglas C. Montgomery, Wiley India Pvt Ltd
4. An Introduction to Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill

PRD5204 Supply chain management

Supply Chain Management: Concepts, theoretical background and managerial issues, Inventory Management and Risk Pooling, Demand Forecasting, Aggregate Planning and MRP, Network Planning, Distribution Strategies, Smart Pricing, Supply Chain Integration, Vendor Development, Procurement and Outsourcing Strategies, Strategic Alliances, Value of Information and IT in SCM, Coordinated Product and supply chain Design, Global Supply Chain, Customer Value and Performance Measurement of Supply Chain.

Suggested Books:

1. Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies by David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi and Ravi Shankar, Tata McGraw-Hill, 2008
2. Supply Chain Management: Strategy, Planning, and Operation by Sunil Chopra and Peter Meindel, Prentice Hall of India.
3. Principles of SCM: A Balanced Approach by Wisner, JD, Leong GK and Tan, KC, Cengage Learning.
4. Supply Chain Management by Janat Shah, Pearson Education

PRD5206 Production & Operation management

Introduction to Production & Operation Management, Management functions of an organization, job design and work measurement: job design decisions, approaches to job design, work measurement standards, learning curves, and its application. Work flow systems; pull & push systems, MRP-I MRP-II, cellular manufacturing and FMS, CIMS, JIT manufacturing, automated production lines, line balancing, facility layout, bottleneck and balance matching, capacity management, Management of professional services. Aggregate planning: aggregate units of production cost in aggregate planning, leave of production strategy, mixed strategy, mathematical model, linear decision rule, master production scheduling shop scheduling, shop floor control, manpower scheduling DRP & demand management.

Suggested Books:

1. Production & operation Management by Chase, Aquilano ,Jacobs –TMH
2. Production & operation Management by James Dilworth, Pearson International
3. Production & operation Management by Jay Heizer, Barry Render, Prentice Hall
4. Production & operation Analysis by Steven Wanmias, McGraw Hill

SEMESTER III

PRD6401 Advanced Machining Processes

Introduction to advanced machining processes – need for such processes and application areas Mechanical Energy utilized advanced machining processes like ultrasonic machining, abrasive flow machining, magnetic abrasive finishing, magneto-rheological finishing, abrasive water jet machining - mechanics of cutting, process parametric analysis, process capabilities, applications; Thermoelectric based advanced machining processes like electro discharge machining, wire EDM, Plasma Arc Machining, Laser Beam Machining, Focused Ion Beam Machining – working principles, material removal mechanisms, process capabilities and applications; Electrochemical and Chemical Advanced Machining – ECG; Electro stream Drilling, Chemical Machining – process characteristics, numerical modelling of the processes, applications and limitations.

Suggested Books:

1. Advanced machining process by Dr. V. K. Jain, Allied Publisers Pvt Ltd
2. Modern manufacturing process by Pandey & shan, Tata McGraw-Hill

PRD6403 Precision Engineering

Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision-Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility; Precision machine element- Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers - Rolling 83 elements – hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings; Error control- Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control – errors due to locations – principle

of constant location surfaces; Precision manufacturing-Micro machining processes-diamond machining - micro engraving - Micro replication techniques-forming-casting-injection moulding - micro embossing - Energy assisted processes - LBM, EBM, FIB, Micro electro discharge machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition; MEMS Introduction – MEMS –characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.,

Suggested Books:

1. Precision Engineering by Venkatesh V.C. and Izman S., Tata McGraw Hill
2. Precision Engineering by Murthy R. L., New Age International
3. Principles of Precision Engineering by Nakazawa H., Oxford University Press

PRD6405 Surface Engineering

Introduction to surface engineering – importance and scope of surface engineering, conventional surface engineering practices like pickling, grinding, buffing etc., surface engineering by material addition like electroplating, surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc. Advanced surface engineering practices like laser assisted surface modification, electron beam assisted modification, spraying techniques like fame and plasma spraying, high velocity oxy-fuel, cold spray techniques. Sputter deposition processes, PVD and CVD methods of surface coatings, surface modification by ion implantation and ion beam mixing Characterization of the engineered surface and coatings like thickness, porosity and adhesion of coatings, surface microscopy and spectroscopic analysis of the modified surfaces. Functional coatings and their applications.

Suggested Books:

1. Introduction to surface engineering and functionally engineered materials by Peter Martin, John Wiley and Sons
2. Tribology and Surface Engineering by J. Paulo Davum, Nova Science Publishing.
3. Material and Surface Engineering in Tribology by Jamal Takadoum, Wiley

PRD6301 Robotics

Introduction: Brief History, Types of robots, Overview of robot subsystems, resolution, repeatability and accuracy, Degrees of freedom of robots, Robot configurations and concept of workspace, Mechanisms and transmission, End effectors and Different types of grippers, vacuum and other methods of gripping. Pneumatic, hydraulic and electrical actuators, applications of robots, specifications of different industrial robots.

Kinematics of Robots: Transformation Matrices, Inverse transformation matrices, Forward and Inverse kinematic equation for position and orientation, Denavit-Hartenberg representation of robot, inverse kinematic solution for articulated robot,

Dynamic analysis of Force: Lagrangian and Newtonian mechanics, Dynamic equations for multiple –DOF Robots, Trajectory Planning: Basics of Trajectory planning, Joint space trajectory planning, Cartesian Space trajectories.

Robot Programming languages & systems: Introduction, the three level of robot programming, requirements of a robot programming language.

Topics on state of the art technology based on latest research papers may be discussed.

Suggested Books:

1. Fundamental Concepts and Analysis by Ghosal A., Robotics, Oxford
2. Introduction to Robotics Analysis by Niku, S. B., Pearson Education
3. Introduction to Robotics: Mechanica and Control by Craig, J. J., Addison-Welsey
4. Fundamentals of Robotics, Analysis and Control by Schilling R. J., PHI
5. Robotics Control, Sensing, Vision and Intelligence by Fu, K, S., Gonzalez R. C., Lee C.S. G., McGraw Hill

PRD6303 Design for Manufacture and Assembly

Product design for life-cycle, concurrent engineering, design for manufacture, rule-based and plan based DFM, automated manufacturability assessment, Automated manufacturability assessment, commonly used tools for design for manufacture and assembly tools including, QFD, POKA YOKE, FMEA, Design for manual assembly and automated assembly, design for environment, Industrial and real life case studies of design for manufacture and assembly.

Suggested Books:

1. Designing for Manufacturing by Harry Peck, Pitman Publications
2. Engineering Metrology by R.K. Jain, Khanna Publication

PRD6305 Reliability Engineering

Introduction: System concepts in reliability, availability and maintainability (RAM) Engineering, Practical applications of RAM Engineering to systems, products and processes; Concepts, terms and definitions; Failure rate function, Probability density function, Cumulative distribution function, reliability function, Mean time to failure (MTTF), MTBF, MTTR etc; Fundamentals of reliability: Failure distributions; Exponential, Weibull, Normal and Lognormal; Constant failure rate model and time dependent failure models; System reliability assessment: Series, Parallel, Combined series-parallel configurations; Cut sets and path sets approach, fault tree analysis (FTA); State dependent systems; Markov analysis, load sharing system, standby system, degraded system, Monte Carlo simulation; Design for Reliability and reliability improvement: Reliability specifications and system measurements, reliability allocation ; exponential case, optimal allocations, arnica method, AGREE method, Various types of redundancies; active and passive redundancy, k-out-of-n- redundancy, standby redundancy, optimization , reliability-cost trade off; Availability and maintainability: Point, mission and steady state availability; Availability assessment, Maintainability and its assessment; Maintenance policies: individual policy, Planned, preventive and condition based maintenance; Opportunistic maintenance policy; Design for maintainability: Maintenance requirements, measurements and specifications, fault diagnosis, failure mode and effect analysis (FMEA), Parts standardization and interchangeability, modularization, accessibility, repair versus replacement, proactive maintenance, maintainability prediction and demonstration.

Suggested Books:

1. Reliability Engineering by Srinath, L. S., East –West Press Ltd., New Delhi
2. Engineering Maintainbility by Dhillon, B. S., Prentice Hall of India, New Delhi

PRD6201 IT in Manufacturing Enterprise

Production Systems, Manufacturing Enterprises as Systems, Appreciate the evolving manufacturing environment and multi-attributed competition: IT role Challenges and Opportunities, Evolving Role of Information Technology in Enterprises: P&I Implications, Technology Management Challenges, Technical Fundamentals: MIS in Manufacturing Enterprises, FMS (Flexible Manufacturing Systems), CIM Systems, Intelligent Manufacturing Systems, Concurrent Engineering and Extended Enterprises, ERP (Enterprise Resource Planning), E-Business and Supply Chain Management, Discrete Event Simulation and AI Applications in manufacturing enterprises, Implementation Issues, Future Trends, Careers etc.

Suggested Books:

1. Information Technology Project Management by Kathy Schwalbe, Cengage
2. Analysis of Manufacturing Enterprises by N Viswanadham, Springer
3. Information Technology for Manufacturing by Kevin Ake, John Clemons, Mark Cubin, Bruce Lilly, CRC press

PRD6203 Materials Management

Scope of materials management, integrated materials management, relation with other functional areas of organization; organizations of materials management, conventional and modern approaches to organizing materials management; Classification, codification, standardization and variety reduction of materials, Inventory control techniques: ABC, VED, FSN; Inventory models; Store Management; Vendor development; Make-Buy decision; Future Trends, etc.

Suggested Books:

1. Purchasing & Supply Management by Dobler & Burt, McGraw-Hill
2. Purchasing & Supply Chain Management by Monczka, Trent & Handfield, Cengage
3. Materials Management by A K Chitle & R C Gupta, PHI
4. Inventory Management by D C Bose, PHI
5. Materials Management by P Gopalakrishnan & M Sundersen, PHI

PRD6205 Project Management

Introduction-Definitions, classifications, and scope of project management; project life cycle and uncertainty; Project planning-Scope, problem statement, project goals, objectives, success criteria, assumptions, risks, obstacles, approval process, projects and strategic planning; Project implementation-Project resource requirement, types of resources: men, materials, finance, resource distribution; Project monitoring-Evaluation, control, project network technique, planning for monitoring and evaluation, project audits, project management information system, Nature of project inventory, supply and transportation of materials, use of Material Requirement Planning. Project scheduling, PERT & CPM, project communication; Project team management-Recruitment, organizing, human resources: team operating rules, project organization, various forms of project organizations, project organization charting, project contracts, principles, compilation of contracts, practical aspects, legal aspects, global tender, negotiations, insurance; Project completion-Closing the project, types of project termination, strategic implications, project in trouble, termination strategies, evaluation of termination possibilities, termination procedures, post project reviews.

Suggested Books:

1. Project Management by Harold Kerzner, Wiley
2. Project Management by Dennis Lock, Gower Publishing Ltd
3. Project Management by Gopalakrishnan, Mcmillan India Ltd,
4. Project Management by Arun Kanda, PHI

Semester IV

PRD652 Research Project

PRD602 Major Project II

DEPARTMENT OF MECHANICAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

Programme : M.Tech. (Thermal Engineering)

Programme Specific Outcomes

1. An ability to identify industrial problems and to provide possible solutions with the help of Engineering tools.
2. An ability of collaborative learning to find out sustainable solution for social issues.
3. Apply the knowledge of Engineering to the solution of complex problems through empathy and creativity.

SCHEME OF TEACHING AND EVALUATION

MASTER OF TECHNOLOGY IN THERMAL ENGINEERING (THE)

The following alphanumeric coding scheme has been adopted
Core Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year),
C – credit of the course (4/3/2),
MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group A	1	THE501	Thermody-namics and Gas Dynamics	Core	4	3	0	2	15	25	20	40	-	17
	2	THE503	Heat Transfer & Fluid Mechanics	Core	4	3	0	2	15	25	20	40	-	
Group B	3	THE5401/5403/.....	Elective 1	Elective	4	3/4	0	2/0	15 /20	25/0	20/ 30	40/ 50	-	
	4	THE5301/5303/.....	Elective 2	Elective	3	3	0	0	20	-	30	50	-	
	5	THE5201/5203/...../ UEC5201/5203/.....	Elective 3/ University Elective I	Elective	2	2	0	0	20	-	30	50	-	

Semester II

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group C	1	THE502	Energy Systems	Core	4	3	0	2	15	25	20	40	-	17
	2	THE504	Turboma-chines	Core	4	3	0	2	15	25	20	40	-	
Group D	3	THE5402/5404/.....	Elective 4	Elective	4	3/4	0	2/0	15/ 20	25/0	20/ 30	40/ 50	-	
	4	THE5302/5304/.....	Elective 5	Elective	3	3	0	0	20	-	30	50	-	
	5	THE5202/5204/...../ UEC5202/5204/.....	Elective 6/ University Elective II	Elective	2	2	0	0	20	-	30	50	-	

Semester III

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group E	Track 1													12
	1	THE651	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	THE601	Major Project I	Core	3						40	60		
	2	THE6401/6403/.....	Elective 7	Elective	4	3/4	0	2/0	15/ 20	25/0	20/ 30	40/ 50	-	
	3	THE6301/6303/.....	Elective 8	Elective	3	3	0	0	20	-	30	50	-	
	4	THE6201/6203/.....	Elective 9	Elective	2	2	0	0	20	-	30	50	-	

Semester IV

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
Group F	Track 1													12
	1	THE652	Research Project	Core	12	0	0	12	0	-	0	100	-	
	Track 2													
	1	THE602	Major Project II	Core	12	0	0	12	0	-	0	100	-	

LIST OF ELECTIVES :

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 1	1	THE5401	Advanced Refrigeration Systems	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	THE5403	Advanced I C Engines		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	THE5405	Power Plant Engg.		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 2	1	THE5301	Computational Methods in Thermal & Fluid Engineering	Elective	3	3	0	0	20	-	30	50	-
	2	THE5303	Optimization Techniques		3	3	0	0	20	-	30	50	-
	3	THE5305	Finite Element Methods		3	3	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 3	1	THE5201	Seminar	Elective	2	2	0	0	2	-	-	100	-
	2	THE5203	Renewable & Non-Conventional Energy Sources		2	2	0	0	20	-	30	50	-
	3	THE5205	Measurement & Control Techniques		2	2	0	0	20	-	30	50	-

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 4	1	THE5402	Advanced Heat Transfer	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	THE5404	Advanced Fluid Dynamics		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	THE5406	Advanced Air Conditioning Systems		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 5	1	THE5302	Minor Project	Elective	3	0	0	-	-	40	0	-	60
	2	THE5304	Solar Engineering Thermal Processes		3	3	0	0	20	-	30	50	-
	3	THE5306	Thermal Energy Conservation		3	3	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 6	1	THE5202	Steam and Gas Turbines	Elective	2	2	0	0	20	-	30	50	-
	2	THE5204	Combustion & Emissions		2	2	0	0	20	-	30	50	-
	3	THE5206	Advanced Cryogenic systems		2	2	0	0	20	-	30	50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 7	1	THE6401	Advanced Power Generation Systems	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	2	THE6403	Micro / Nano scale Heat Transfer		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	3	THE6405	Combustion Modelling		4	3/4	0	2/0	15/20	25/0	20/30	40/50	-
	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 8	1	THE6301	Advanced Heating Ventilation & Air Conditioning	Elective	3	3	0	0	20	-	30	50	-
	2	THE6303	Two Phase Flow Heat Transfer		3	3	0	0	20	-	30	50	-
	3	THE6305	Exergy Analysis of Thermal Systems		3	3	0	0	20	-	30	50	-

	S. No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective 9	1	THE6201	Advanced Energy Systems	Elective	2	2	0	0	20	-	30	50	-
	2	THE6203	Dynamics and Control of Mechanical Systems		2	2	0	0	20	-	30	50	-
	3	THE6205	Alternative Fuels		2	2	0	0	20	-	30	50	-

SEMESTER I

Courses

THE501 Thermodynamics and Gas Dynamics

Review of first and second law of thermodynamics, thermodynamic relations, Joule-Thompson experiment, irreversibility and availability, exergy analysis, phase transition, types of equilibrium and stability, multi-component and multi-phase systems, equations of state, chemical thermodynamics, combustion.

Third law of thermodynamics, kinetic theory of gases, principle of equipartition of energy, classical theory of specific heat capacity. The Van der Waals equation of state.

Statistical thermodynamics, energy states and energy levels, macro and micro scales, thermodynamic probability, statistical interpretation of entropy, application of statistics to gases, distribution of molecular velocity, ideal gas in a gravitational field.

Basis concepts to Gas Dynamics, isentropic flow with variable areas, mach number variation, flow through nozzles and diffusers, use of gas tables, Fanno & Rayleigh lines and tables.1-D and 2-D steady isentropic flow, Flow in ducts of variable area, Viscous effects in Compressible Flow, Design of Nozzles, Normal and oblique shock waves, Prandtl-Mayer expansion, Supersonic Airfoils, Simple and shock waves, Boundary .Layer interactions,

Thermodynamic properties, Hypersonic Flow and High Temperature Flows, Equilibrium and Non-Equilibrium Flow.

Latest innovations/ research work in the field of Thermodynamics and Gas Dynamics.

Suggested Books:

1. Wylen and Sontag, Fundamentals of Classical Thermodynamics, Wiley Eastern Limited, New Delhi.
2. M. J. Moran and H. N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.

THE503 Heat transfer and Fluid Mechanics

Fluid Kinematics, Navier-stokes equation-exact and approximate solution for few simple cases, creeping flow. Boundary layer theory, Approximate solution procedures for boundary layer problems, separation and control.

3-dimensional boundary layers. Turbulence phenomena and its measurement, Turbulent diffusion and turbulent shear flow. Free turbulent flow, determination of profile drag and various experimental techniques used for determination of drag. Concept of computational fluid dynamics.

Steady state heat conduction including heat generation and heat losses in different coordinate systems numerical and graphical methods. Concepts of isotropic & homogenous conductivity.

Analysis and Optimization of variable cross section and circumferential fins; Extended surfaces with relative motion; wire drawing.

Conduction in solids with complex boundary conditions. Numerical solutions for transient and steady conduction problems.

Fundamental laws of radiation, Configuration factors; Radiation heat transfer through absorbing and transmitting media; Radiation exchange with specular surfaces, radiation shielding.

Latest innovations/ research work in the field of heat transfer and fluid mechanics.

Suggested Books:

1. Fluid Mechanics by Frank M. White, McGraw Hill
2. Fluid Mechanics by Som and Biswas , TMH

THE5401 Advanced Refrigeration Systems

Thermodynamic analysis of VCR cycles, multistage vapor compression cycles. Cascade refrigeration, manufacture of dry ice, liquefaction of gases, cryogenic applications. Cold storage, refrigeration and air conditioning controls.

Refrigerants and its types, ODP and GWP of important refrigerants, Montreal & Kyoto Protocol, Alternatives to important CFCs, HCFCs and HFCs, Modern trends in Refrigeration and Air conditioning industry. Retrofitting, Recovery, Recycling and Reclaim.

Vapor absorption systems analysis, use of enthalpy composition diagram. Performance parameters using P-Tdiagrams. Design of refrigerant condensers, evaporators and expansion devices.

Suggested Books:

1. Refrigeration & Air Conditioning by W F Stoecker and J W Jones, McGraw Hill
2. Principles of Refrigeration by Dossat R.J. Wiley & Sons

THE5403 Advanced I.C. Engines

Fuel Air cycles analysis, Thermodynamics of combustion, Chemical equilibrium, Dissociation, Combustion Charts and gas tables for air fuel mixtures and the products of Combustion.

Combustion phenomenon in S.I. and C.I. Engines, Detonation and knocking, Influence of variables on knocking, Types of Combustion Chambers. Exhaust emission from SI and CI engines, control of emissions.

Required properties of Fuels for IC engine, alternative fuels, rating of fuels.

carburetion, Fuel spray characteristics. High pressure fuel pump and its design.High and low tension ignition systems. Ignition timing.

Effect of operating and design conditions on the performance of Engine.

Scavenging in Two stroke engines, mechanical friction, pumping H.P. of engines, Lubrication systems. Supercharging of S.I. and C.I. Engines. Effects of operating variables on supercharged engines. Free piston engines.

Characteristics of I.C. engines used in automobile, engine cooling.

Latest innovations/ research work in the field of I.C. Engines.

Suggested Books:

1. Internal combustion engine fundamentals by JB Heywood, McGraw Hill
2. Internal combustion engine by R P Sharma and M L Mathur, Dhanpat Rai Publications

THE5405 Power Plant Engineering

Power development program of India. Factors controlling the choices of various conventional and non-conventional power plants. Important specifications of the plant. Steam power cycle analysis. Economic aspect of power generation, Availability based tariff, performance parameters.

Criteria affecting steam generator design. Determination of furnace size and proportions of various heat transfer surfaces. Influences of fuel quality, fuel firing techniques and Circulation on design, selection of auxiliary equipment.

Design principles of feed water heaters, condensers, cooling towers etc. Controls used in steam power plants. Supercritical power plant, function of separator/ drum. Improvement in performance of supercritical and ultra-critical power plant.

Types of Nuclear power plants in India and their working. Strategy of nuclear power development in India, integrated energy systems, energy conservation and energy audit, devices for energy conservation.

Latest innovations/ research work in the field of power plant engineering.

Suggested Books:

1. Power plant engineering by P K Nag, Tata McGraw Hill
2. Power plant engineering by Samsher Gautam, Vikas Publication.

THE5301 Computational Methods in Thermal & Fluid Engineering

Brief overview of numerical methods; Governing equations in Heat Transfer and Fluid Dynamics.

Introduction to equations governing turbulent flow and heat transfer. Boundary conditions, Various explicit and implicit schemes. Solutions of parabolic and elliptic partial differential equations.

Finite difference method of discretization, Finite difference approximation and truncation error, round off error and discretization error; Accuracy, Consistency, Stability and Conveyance.

Various discretization schemes and their stability and accuracy.Solution methods for boundary layer equations in impressible flow and convection. Unsteady flows.

Latest innovations/ research work in the field of Computational Methods in Thermal & Fluid Engineering.

Suggested Books:

1. Computer Simulation of Flow & Heat Transfer by Ghoshdastidar, P.S. Tata McGraw Hills, 1998.
2. Computational Fluid Mechanics & Heat Transfer by Anderson, D.A., Tanelldil, J.C. & Platcher,

THE5303 Optimization Techniques

Introduction to Optimization: Engineering Applications, Statement of Optimization Problems.

Linear Programming: Simplex Algorithm; Two Phase Method, Big 'M' Method, Duality in Linear Programming; Sensitivity and Post Optimality Analysis. Transportation and Assignment Problem.

Dynamic Programming:Concepts of Dynamics Programming, Multi stage Decision Process, Calculus Method and Tabular Method.

Classical Optimization techniques – Unconstrained andConstrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Lagrange Multipliers Method. Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary & sufficient conditions.

Non-Linear Programming-Unconstrained Optimization Techniques: Direct search methods, Descent Methods. Constrained Optimizations: Direct and Indirect methods.

Introduction to Advanced Optimization Techniques -Genetic Algorithms (GA), Simulated Annealing, Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) etc.

Suggested Books:

1. Operations Research by Hamdi A. Taha, Publisher: Pearson
2. Engineering Optimization by S.S. Rao, Publisher: JOHN WILEY & SONS, INC.

THE5305 Finite Elements Methods

Introduction to Finite Element Method. Difference between Finite Element and Finite Difference Methods.

Method of Weighted Residuals: Collocation, Method of Least squares, Galerkin's method, Element of Calculus of Variations, Ritz Method, Equivalence of Ritz and Galerkin method for some cases.

Linear, quadratic and higher order elements. Application to solutions of ODE. Assembly and solution of banded system. Introduction, Difference between 1D and 2D approach, types of 2D elements, Local coordinates, Global coordinates.

Triangular elements: linear and quadratic elements with area coordinates Rectangular elements: General Quadrilateral elements, serendipity elements, linear and higher order shape functions.

Assembly of element equations, Solution of equations Application to flow and heat transfer problems, Discussion over higher order differential equations Some programming aspects: Mesh Generation, Mesh refinement, Numerical integration etc.

Introduction to Meshless Galerkin methods: Difference between Meshfree and FEM methods, Choice of approach, and interpolating polynomials, variational formulation,Application to some simple problem.

Suggested Books:

1. An Introduction to Finite Element Method by J. N. Reddy, McGraw Hill
2. Applied Finite Element Analysis by L. S. Segerlind, John Wiley
3. The Finite Element Method in Engineering by S. S. Rao, Pergamon

THE5203 Renewable & Non-conventional Energy Sources

Earth sun energy flux diagram, Overview of renewable energy conversion, energy resource assessment: Solar radiation and modeling.

Solar collectors and types, advanced collectors and solar concentrators,Applications of solar energy, Solar thermal power generation, photovoltaic energy conversion, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options.

Sources of Bio-Mass Energy – Wood, Agricultural, Animal Waste – Biogas Generation, Wood Gasification - Downdraft and Fluidized Bed Systems.

Tidal and wind energy,Mini / micro hydro power, basics of wave, tidal, OTEC, hydrogen and fuel cells.

Latest innovations/ research work in the field ofRenewable & Nonconventional Sources of Energy.

Suggested Books:

1. Renewable Energy Resources by John Twidell and Tony Weir, Taylor and Francis
2. Renewable Energy Sources: Basic Principles and Applications by G. N. Tewari and M. K. Ghosal, Narosa Publishing

THE5205 Measurement & Control Techniques

Generalised measurement system: Functional elements of Instrument. Description and usages of transducers, intermediate stage and terminal devices including various indicating and recording devices.

Static and Dynamic characteristics of measurement systems. Harmonic and special waveforms and their analysis. Measurement standards, Calibration need and procedure, Errors in measurement systems and statistical interpretation of experimental data.

Various Measurement techniques with standard of measurement, principle, construction and working for displacement, strain, velocity, acceleration, force, Static and Dynamic pressure, temperature and fluid flow Control: Types of Control Systems, Types of controllers,

Mathematical modelling and transfer function, Control Applications.

Latest innovations/ research work in the field of Measurement & Control Technique.

Suggested Books:

1. Measurement Systems- Application and Design by E O Doebelin
2. Measurement Devices and Systems by Rangan, Mani and Sharma, Tata McGraw-Hill
3. Instrumentation, Measurement and Analysis by B C Nakra and K K Chaudhary, Tata McGraw-Hill

SEMESTER II

THE502 Energy Systems

Fuel Cells: Components, Electro chemistry and Thermodynamics, Types of Fuel Cell.

Bio-fuels: Sources of Bio-Mass Energy-Wood, Agricultural, Municipal and Animal Waste, Energy Conversion Systems. Biogas Generation, Wood Gasification - Downdraft and Fluidized Bed Systems

Vegetable Oils: Conversion of vegetable oils as biodiesel –production techniques - standards and properties - combustion performance and Emission characteristics, additives.

Alcohol Fuels: Properties as engine fuels - performance in SI and CI engines - blending with gasoline - Reformed Alcohols - emulsions - dual fuel systems - combustion, performance and emission characteristics in IC engines.

DME, DEE properties, production techniques, performance and emissions characteristics in IC engines.

Latest innovations/ research work in the field of Energy Systems.

Suggested Books:

1. Gasoline, Diesel and Ethanol Biofuels from Grasses and Plants by Ram B. Gupta, Cambridge University Press
2. Introduction to Biofuels by David M. Mousdale, Taylor & Francis

THE504 Turbo Machines

Thermodynamics of Turbomachines-Basic definition and laws, energy equation, adiabatic flow through nozzle and diffuser, work and efficiencies in turbine and compressor stages

Fluid dynamics of Turbomachines- flow over Aerofoil blades, Energy transfer in Turbo machines, Boundary layer separation. compressible flow machines, Performance of turbine, compressor, fans, blowers and cascade.

Axial flow Turbo machines-velocity diagrams. Single and multi-impulseturbine stage(velocity and pressure compounded),stage-reaction, Blade to gas speed ratio, Stage losses and efficiency and performance characteristics..

Radial & Centrifugal Turbo machines - Elements and velocity triangle of radial turbine stage, enthalpy entropy diagram, stage losses, performance slip factor, diffusers,volute casing, stage losses, performance characteristics.

Suggested books:

1. Turbines, compressors and Fans by S. M. Yahya, Tata McGraw Hill
2. Steam & Gas Turbines by J. F. Lee, McGraw Hill

THE5402 Advanced Heat Transfer

Conduction: Steady state heat conduction including heat generation and heat losses in different coordinate systems numerical and graphical methods.

Analysis and Optimization of variable cross section and circumferential fins; Extended surfaces with relative motion; wire drawing. conduction in solids with complex boundary conditions; Numerical solutions for transient and steady conduction problems.

Fundamental laws of radiation, Configuration factors; Radiation heat transfer through absorbing and transmitting media; Radiation exchange with specular surfaces; Radiation exchange with transmitting, reflecting and absorbing media, Solar radiation and radiation shielding.

Concept of Boundary Layer, Derivation of N-S equation; Tensor and Vector Notations; Mass Transfer Equations of Boundary Layer, Momentum and Energy Equation for Flow over or inside and axis symmetric body: displacement, momentum, conduction and enthalpy thickness;

Solution for constant free stream and variable free stream velocities over a curved surface; Flow over a constant temperature body of arbitrary shape; Fully developed laminar flow in circular tube; Laminar constant heat flux and constant wall temperature solutions.

Condensation, boiling heat transfer-different regimes, transpiration cooling, Combined free and forced convection; Fundamental of turbulent heat convection; Forced and natural flow boiling.

Latest innovations/ research work in the field of Heat Transfer.

Suggested Books:

1. Heat Transfer by J.P. Holman, International Edition, McGraw Hills.
2. Convective Heat & Mass Transfer by W.M. Kays and M.E. Crawford, McGraw Hills.

THE5404 Advance Fluid Dynamics

Basic concepts and fundamental, governing equation of fluid motion, exact solution of Navier stokes equation, potential flows, laminar boundary layers, elements of stability theory, turbulent flow, compressible flow, introduction to CFD.

Suggested Books:

1. Advanced fluid dynamics by Hyoung Woo Oh, InTech.
2. Physical Fluid Dynamics by D. J. Tritton, Springer

THE5406 Advance Air Conditioning Systems

Introduction to Psychrometric Processes, Comfort Conditioning (ASHRAE Standards), Solar Geometry & Heat gain through walls and windows, Cooling Tower Design, Heating and Cooling Coil Design, Fans & Duct Design

Suggested Books:

1. Refrigeration and Air Conditioning by C P Arora, Tata McGraw-Hill

THE5304 Solar Engineering Thermal Processes

Energy and Dependence on External Sources and Sun, Physical Descriptions and Reactions, Sun - Earth Geometry, Terminology Extra - Terrestrial Radiation Terrestrial Radiation, Measuring Instruments, Estimation of Solar Radiation, Radiation Processing - Long Term, Evaluation of the Apparent Sunrise and Sunset Angles, Estimation of Daily/Monthly Tilt Factor Under Terrestrial Conditions, Solar Collector Basics, Transmission - Absorptance Product, Transmittance - Absorptance Product Analytical Evaluation, Theory of Flat Plate Collectors, Concentrating Collectors

Latest innovations/ research work in the field of Solar Engineering Thermal Process.

Suggested Books:

1. Solar engineering of thermal processes by John Duffie and William A. Beckman, Wiley
2. Solar Energy: Principles of Thermal Collection and Storage by S P sukhatme and J K Nayak, McGraw Hills.

THE5306 Thermal Energy Conservation

Waste Heat Recovery, Power Plant Cycles - Energy Cascading, Rankine Cycle and it's modification

Gas Turbine Cycle, Combined cycle Power Plant, Heat Recovery Steam Generators.

Cogenerations, Heat Exchangers Analysis, Problem solving, Special Heat Exchangers for Waste Heat Recovery. Heat pipes & Vapour Chambers, Direct conversion technologies – Thermoelectric Generators. Thermoionic conversion, Thermo-PV, MHD

Pumped hydro, Compressed Air, Flywheel, Superconducting Magnetic storage, Thermal storage

(Sensible & Latent), Battery, Chemical Energy Storage, Fuel cells.

Energy Economics

Suggested Books:

1. Thermal Energy Storage Technologies for Sustainability by S. Kalaiselvam and R. Parameshwaran, Elsevier Science
2. Energy conservation by Woodhead Publishing

THE5202 Steam and Gas Turbines

Review of Thermodynamics, Rankine, Binary Vapour Cycle and Co-generation.

Boilers Types, Mountings and Accessories, High Pressure Boilers, Draught, Performance of Boilers, Combustion of Fuel Boiler Trial.

Nozzles and Diffusers-Momentum and Continuity Equations, Efficiency and Critical Pressure, General Relationship and supersaturated Flow.

Impulse Steam Turbines, Compounding, Performance. Impulse-Reaction Steam Turbines-Performance, Energy Losses, Condensers. Gas Turbine Cycles- Performance Evaluation, Modifications.

Centrifugal Compressors, Axial Flow Compressors, Jet Propulsion.

Suggested Books:

1. Steam and Gas Turbines and Power Plant Engineering,by Dr. R. Yadav, Central Publishing House, Allahabad
2. Steam Turbines by Walter S. Leland, American Technical Society

THE5204 Combustion and Emissions

Thermodynamics of Combustion. Types of reactions, reaction rate, effect of composition and temperature on reaction rates. Arrhenius law, kinetics of chain reactions, steady state reaction rate. Detonation waves in gases. Hurgoniet curve, detonation velocity. Detonation theories, Factors influencing detonation. Adiabatic Explosion in constant volume bombs.

Flame Propagation-Theories, structure of Laminar flame, flame velocity and its estimation, factors controlling flame velocity, diffusion and stabilization of flame. Ignition theory, Ignition energy, factors affecting ignition, various methods of ignition.

Combustion of fuels-coal flames and two stage ignition, mechanism of hydrocarbon oxidation, rate of combustion, propellant burning. Combustion process in Rockets, Ramjets-solid and liquid propellants, mono Propellant and bipropellant systems.

Chemical Emission from combustion, Quantification of emission, Emission control methods

Latest innovations/ research work in the field of Combustion.

Suggested Books:

1. Combustion engineering by Gary L. Borman, Kenneth W. Ragland, McGraw-Hill
2. An introduction to combustion by Stephen R. Turns, McGraw-Hill

THE5206 Advanced Cryogenics Systems

Introduction to Cryogenic Engineering, Properties of Cryogenic Fluids, Properties of Materials at Cryogenic Temperature, Gas Liquefaction, Gas Separation, Cryocoolers, Cryogenic Insulations, Vacuum Technology, Instrumentation in Cryogenics, Safety in Cryogenics. Latest innovations/ research work in the field of Cryogenics Systems.

Suggested Books:

1. Cryogenic Systems: Advanced Monitoring, Fault Diagnostics, and Predictive Maintenance by Pasquale Arpaia, Mario Girone, Vitaliano Inglese, and Marco Pezzetti Momentum Press.
2. Cryogenic Systems by Randall F. Barron, Oxford University Press

SEMESTER III

THE6401 Advance Power Generation System

Overview of the Indian power sector, Thermodynamic analysis of Conventional Power Plants. Advanced Power Cycles, Kalina (Cheng) Cycle, IGCC, AFBC/PFBC

Steam Turbine - Superheater, reheater and partial condenser vacuum. Combined Feed heating and Reheating. Regenerative Heat Exchangers, Reheaters and Intercoolers in Gas Turbine power plants. Hydro power plants - turbine characteristics. Auxiliaries - Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurisation, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers.

Power plant control systems- Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks

Analysis of System load curve -plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling Pricing of Power - Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies Optimal Dispatch - Scheduling of Hydro-Thermal plants. Load Forecasting - Time series, Econometric, end use techniques. Least Cost Power Planning - Integration of DSM, Renewable into supply.

Suggested Books:

1. Power Plant Performance by A. B. Gill, Butterworths
2. Power Generation, operation & control by A. J. Wood and B. F. Wollenberg, John Wiley

THE6403 Micro / Nano Scale Seat Transfer

Introduction, Fundamentals of Quantum Mechanics, Fundamentals of solid state physics, Fundamentals of statistical thermodynamics, various transport processeses, Nano fluids, Measurement techniques.

Suggested Books:

1. Microscale and Nanoscale Heat Transfer: Fundamentals and Engineering Applications by C.B. Sobhan and G.P. Peterson, CRC Press
2. Microscale and Nanoscale Heat Transfer, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.

THE6405 Combustion Modelling

Critical consideration in combustion phenomenon, simple combustion reacting system model, Effects of turbulence on flame propagation Some fundamental aspects of combustion modeling for numerical modeling of premixed and diffusion turbulent combustion, Eddy break-up model and its expansion, Eddy dissipation model, simplified PDF model with different reaction rate and flame surface, and flame let model.

Suggested Books:

1. Internal Combustion Engine Fundamentals by John B. Heywood, McGraw Hills
2. Internal combustion engine by R P Sharma and M L Mathur, Dhanpat Rai Publications

THE6301 Advanced Heating Ventilation & Air Conditioning

Psychrometry, simple psychometrics processes, use of psychometrics chart. Comfort and industrial air conditioning. Air filtration. Principles of ventilation. Physiological factors. Comfort index. Air conditioning systems: Spray systems, chilled water and DE Coils, absorption and adsorption systems. Humidifiers. Air conveying: fans, ducts and air diffusion equipment. Estimation of air conditioning load, determination of supply state. Applied psychrometry, load estimation, Design and constructional details of Unitary air conditioning equipment. Noise level and acoustic control. Automatic controls in air conditioning. air duct design. Latest innovations/ research work in the field of refrigeration systems.

Suggested Books:

1. Refrigeration and Air Conditioning by C P Arora, McGraw Hills
2. Heating, Ventilating and Air Conditioning: Analysis and Design by Faye C Mcquipon, Jerald D Parker and Jeffrey D Spitler, Wiley

THE6303 Two Phase Flow and Heat Transfer

Introduction, Flow Regimes, Homogeneous Flow, Drift Flux, Separated Flow, Bubbly, Slug, Annular and Stratified Flow, Measurement of Void Fraction, Signal Analysis, Two Fluid-Population Balance Technique, Volume of Fluid Method, Lattice Boltzmann Model, Smoothed Particle Hydrodynamics, Molecular Dynamics, Boiling, Condensation, Solid Liquid Flow, Gas-Solid-Flow.

Suggested Books:

1. Microgravity Two-phase Flow and Heat Transfer by Gabriel, Kamiel S, Springer
2. Two-Phase Flow and Heat Transfer by P. B. Whalley, Oxford University Press

THE6305 Exergy Analysis of Thermal Systems

Review of Second Law of thermodynamics, Reversible heat engine, Exergy balance for a closed and open system, Irreversibility, Entropy generation in closed and open systems. Maximum work in a chemical reaction, Basic Exergy concepts, Exergy analysis of different processes, Exergy analysis of power and refrigeration cycles.

Suggested Books:

1. Exergy :Energy, Evironment and Sustainable Development by Ibrahim Dincer and Marc A Rosen, Elsevier
2. The Exergy Method of Thermal Plant Analysis by T J. Kotas, Butterworths

THE6201 Advance Energy System

Energy sources: Fuels: Fossil fuels, Nuclear fuels, Direct Solar, Indirect solar - Biomass, Ocean, Tidal, Hydro, Wind etc. Energy demand/ Growth/ economics; Fuel upgradation: gasification of coal and biomass; biogas Energy conversion: Direct Conversion: Solar PV, Fuel Cells, and Thermo-electric Conversion. Thermal to electric: IC Engines, Gas and Steam Turbines; Electromechanical conversion; Hydraulic turbines. Chemical to Thermal: Combustion and stoichiometry. Energy utilization: Refrigeration, HVAC, Desalination, Poly generation; pumps and compressors Energy storage: Thermal / Mechanical / Electric / Chemical Environmental Impact: Air/ water / soil / nuclear waste.

Suggested Books:

1. Advanced Energy Systems (Energy Technology Series) by Nikolai V. Khartchenko and Vadym M. Kharchenko, CRC Press

THE6203 Dynamics and Control of Mechanical System

Mechanics of particle motion, momentum and energy principles. Hamilton's, D' Alembert's principle, Lagrange's equation applied to conservative and non-conservative systems. Space and body fixed co-ordinates, Euler angles, multibody systems, planer dynamic analysis. Stability of dynamical systems, Liapunov's direct method and theorems, Routh's stability criteria. Open and closed loop systems, proportional, integral and derivative control actions and their characteristics.

Suggested Book:

1. Dynamics and Control of Mechanical Systems by Michael J. Enos, American Mathematical Society

THE6205 Alternative Fuels

Need for Alternative Fuels: Greenhouse effect, Factors affecting greenhouse effect. Emission norms as per Bharat Standard up to BS – IV and procedures for confirmation on production.

Alcohol: Sources of Methanol and Ethanol, methods of its production. Properties of methanol & ethanol as engine fuels, Use of alcohols in S.I. and C.I. engines, performance of blending methanol with gasoline. Emulsification of alcohol and diesel. Dual fuel systems. Improvement / Change in emission characteristics with respect to % blending of Alcohol.

Bio Diesels: Base materials used for production of Bio Diesel (Karanji oil, Neemoil, Sunflower oil, Soyabeen oil, Mustard oil, Palm oil, Jatropha seeds). Process of separation of Bio Diesel. Properties Diesel blended with vegetable oil, and difference in performance of Engine.

Biogas, solar power, electric and hybrid vehicles, vegetables oil.

Suggested Book:

1. Alternative Fuels for Transportation by Arumugam S. Ramadhas, CRC Press

Semester IV

THE652 Research Project

THE602 Major Project II

Procedure for Conduct and Evaluation of XXX 651- M.Tech Research Project in Track-1

(*XXX represents the department code)

a) In second year (i.e. III and IV Semester) Track 1-option is by "Research Project". The course will be offered to the students in the III semester. Head of the department shall appoint a project coordinator on the advice of BoS from amongst the faculty members of the department who will act as the course coordinator.

b) The end term project examination will be carried out at the end of IV Semester (for 24 credits), by June 30 of the respective year. For this purpose, the supervisor will act as an internal examiner. Further, two external examiners (Outside the University) will be proposed by the course coordinator, as per the recommendations of BoS, to the COE, who will then forward it to the Vice Chancellor for nomination of one expert.

c) The students will be required to submit two soft bound copies (spiral bound) and one soft copy of the thesis in a CD along with duly completed prescribed Thesis Submission Form and plagiarism report in original issued from Library and proof of fee submission, to HoD of the respective department. Thesis submission form can be downloaded from the DTU website.

d) The respective departments will forward the M.Tech Thesis soft copies alongwith the aforesaid attachments to the Examination Branch for sending it to the examiner (s) for evaluation.

e) The Examination Branch will in-turn dispatch the M.Tech thesis soft copy to the concerned examiner (s) for evaluation.

f) The final examination may be in the form of demonstration in the laboratory and viva-voce or only viva-voce depending upon the nature of the project.

g) The supervisor (internal examiner) and the external examiner will award marks to individual students and will compute grades in accordance with the prescribed procedures as given in point B below.

h) The final hard bound M.Tech thesis/dissertation will be submitted to the respective Department and Library before taking no dues.

i) All the grades will be submitted to the COE for onward submission.

A. Course Details and Publication Acceptance Criteria:

The students will be allowed to earn 24 credits at the end of IV Semester on the basis of his/her publication provided:

- The research work is accepted or published in Category 1 or Category 2 journals as mentioned in point C;
- The research paper should be solely between the faculty advisor and the student. Further, there cannot be any other co-author from outside/inside the university in the publication.

B. Grading of Research Work:

The candidate will be atleast awarded A+ and A grade if published in category 1 and category 2 respectively, as detailed in C below.

Publication Category	Grade
Premier Research Category (Category 1)	O or A+
Commendable Research Category (Category 2)	A+ or A

C. Categories of Publication:

The publication made in the journals, which seeks publication fee (article processing charges or open access charges), shall not be considered for irrespective of the listing in the publication societies/ houses/presses specified in the following lists:

Category 1) Premier Research Publications

The research publication must be in a journal of impact factor at least one, indexed in SCI/SCIE/ SSCI and published in the following:

1. Proceedings of Royal Society
2. American Mathematical Society
3. American Physical Society
4. American Society for Civil Engineers (ASCE)
5. American Society for Mechanical Engineers (ASME)
6. IEEE Transactions
7. Association for Computing Machinery (ACM) Transactions
8. Institute of Civil Engineering Publishing, London
9. Institute of Mechanical Engineering, London
10. American Society of Testing Materials (ASTM)
11. Nature Publishing Group

In addition to the above list, the SCI/SCIE/SSCI journals with impact factor equal to or more than thirty (30) will be also be considered.

Category 2) Commendable Research Publications

The research publication must be in a journal of impact factor at least one, indexed in SCI/SCIE/ SSCI and published in the following:

1. IEEE Journals
2. Springer
3. Elsevier (Science Direct)

4. Oxford University Press
5. Pergamon-Elsevier Science Ltd.
6. Cambridge University Press
7. Wiley-Blackwell
8. Blackwell Publishing
9. John Wiley & Sons
10. Institute of Engineering and Technology (IET)
11. Biomedical Central Ltd.
12. MIT Press
13. Indiana University Press
14. America Meteorological Society
15. American Physiological Society
16. American society for Microbiology
17. American Chemical Society
18. American Institute of Physics
19. IOP Publishing Ltd.
20. Massachusetts Medical Society
21. IOS Press
22. Princeton University Press
23. Society of Industrial and Applied Mathematics
24. Proceedings of National Academy of Sciences of USA

In addition to the above list, SCI/SCIE/SSCI journal not included in the above list having impact factor equal to or more than five shall also be considered.

Procedure for Conduct and Evaluation of XXX 601- M.Tech Project-I

a) This course will be offered in the III Semester of the M. Tech. program.

b) Head of the department shall appoint a project coordinator on the advice of BoS from amongst the faculty members of the department who will act as the course coordinator.

c) The progress of students will be monitored by their respective supervisors.

d) The evaluation will be based upon Mid-Term examinations (MTE) and an End-Term examination (ETE) with a weightage of 40% and 60% respectively.

e) The Mid-Term examination will involve report submission, presentation and oral viva-voce. For this purpose, suitable committees will be constituted by the BoS for evaluation of report, presentation and oral viva-voce. The project examination committees will award marks to individual students and forward them to the project coordinator who will maintain these records.

f) The end term project examination will be carried out at the end of III semester (for 3 credits), within 10 days from the last theory paper. For this purpose, suitable examination committees will be appointed by the BoS in consultation with the project coordinator, with at least one external examiner. In case an examiner from outside the University is not available, faculty member of the University from outside the Department may be appointed as an external examiner after taking his/her consents.

g) The students will be required to submit a final project report to the project coordinator, at least 3 days before the date of final project examination.

h) The final examination may be in the form of demonstration in the laboratory and viva-voce or only viva-voce depending upon the nature of the project.

i) The examination committee will award marks to individual students and forward them to project coordinator.

j) The Grade Moderation committee for the course will be the same as that for other courses of the class.

Procedure for Conduct and Evaluation of XXX 602- M.Tech Project-II

a) This course will be offered in the IV Semester of the M. Tech. program.

b) Head of the department shall appoint a project coordinator on the advice of BoS from amongst the faculty members of the department who will act as the course coordinator.

c) The end term project examination will be carried out at the end of IV Semester (for 12 credits), by June 30 of the respective year. For this purpose, the supervisor will act as an internal examiner. Further, two external examiners (Outside the University) will be proposed by the project coordinator, as per the recommendations of BoS, to the COE, who will then forward it to the Vice Chancellor for nomination of one expert.

d) The students will be required to submit two soft bound copies (spiral bound) and one soft copy of the thesis in a CD along with duly completed prescribed Thesis Submission Form and plagiarism report in original issued from Library and proof of fee submission, to HoD of the respective department. Thesis submission form can be downloaded from the DTU website.

e) The respective departments will forward the M.Tech Thesis soft copies alongwith the aforesaid attachments to the Examination Branch for sending it to the examiner (s) for evaluation.

f) The Examination Branch will in-turn dispatch the M.Tech thesis soft copy to the concerned examiner (s) for evaluation.

g) The final examination may be in the form of demonstration in the laboratory and viva-voce or only viva-voce depending upon the nature of the project.

h) The supervisor (internal examiner) and the external examiner will award marks to individual students and will compute grades in accordance with the prescribed procedures as given in Project Grade Table below.

i) The final hard bound M.Tech thesis/dissertation will be submitted to the respective Department and Library before taking no dues.

j) The research paper should be solely between the faculty advisor and the student. Further, there cannot be any other co-author from outside/inside the university in the publication.

k) All the grades will be submitted to the COE for onward submission.

Project Grade Table

Grade	Conditions to be fulfilled
O or A+	One paper accepted/published in SCI/SCI expanded/SSCI/ Scopus indexed journal and on the basis of performance during the viva voce.
A+ or A	Two good quality full-length papers accepted/published in peer reviewed Scopus indexed conferences and on the basis of performance during the viva voce.
B+/B/C/P/F	On the basis of performance during the viva voce.

List of University Electives

University Elective I

1. Entrepreneurship Development.
2. Stress Management by Yoga.
3. Research Writing.
4. Ethics & Human Values.
5. Engineering Economics.
6. Business Communication & Presentatioon Skills.
7. Communication Skills.
8. Ethics & Technology.

University Elective II

1. Financial Data Analytics.
2. Technical Report Writing.
3. Cost Management of Engineering Projects.
4. Business Analytics.
5. Intellectual Property Rights.
6. Technical Communication.
7. Logical Reasoning & Critical Thinking.
8. Multimedia Tools & Technology.
9. Data Analytics.

Syllabus of University Elective Courses

University Elective I

Entrepreneurship Development

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5201	Entrepreneurship Developent	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The goal of this course is to develop entrepreneurship skills and create an understanding towards the business model development. The course inclues the concept of entrepreneurship and economic development, the factors including entrepreneurial growth, classification and types of entrepreneurs, entrepreneurial competencies and EDP programs. It also encompasses the opportunity/identification and product selection, various enterprises launching formalities and role of support institutions and management of small business.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	F. Donald F. & Dr. Kuratko, "Entrepreneurship: Theory, Process and practice", South Western Publication.	2016
	Reference Books	
2.	Charantimath, "Entrepreneurship Development and Small Business Enterprise", Pearson Education.	2013
3.	T. Kalpana, Entrepreneurship Theory and Practice, Anmol Publication Pvt. Ltd, Delhi.	2014

Stress Management by Yoga

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5203	Stress Management by Yoga	Elective	2	0	0	4	No	Yes	0	0	-	30	70

Pre-requisite: None

Details of Course

This course contains topics of Introduction to Yoga: Origin of Yoga & its brief development Meaning of Yoga & its importance Yoga as a Science of Art (Yoga Philosophy). Meaning of mediation and its type and principles. Classification of Yoga/Types, Meaning of Asana, its types and principles. Yogic therapies and modern concept of Yoga Naturopathy, Psychology of mantras. Different mudras during prayers. Effect of Asanas on various Systems Differences between Asana and Exercise. Difference between Pranayama and deep breathing. Yogic Diet.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	B. S. Miler, " Yoga: Discipline of Freedom: The Yoga Suntra Attributed to Patanjali", New York: Bantam Books.	1998
2.	D. Swenson, "Ashtanga Yoga: The Practice Manual: An Illustrated Guide to personal Practie", Atlantic Publishers.	2007
3.	R. Walsh, "Essential Spirituality", John Wiley and Sons.	2000
	Reference Books	
4.	D. Chopra, "Seven Spiritual Laws of Success: A Practical Guide to the Fulfillment of Your Dreams", Amber-Allen Publishing.	1994
5.	S. Cope, "Yoga and the Quest for the True Self", Bantam Books.	2018
6.	W. W. Dwyer, "The Power of Intention", Hay House.	2010
7.	B. K. S Iyengar, "Light on the Yoga Suntras of Patanjali", Thorsons.	2012
8.	B. K. S. Iyengar, Light on Pranayama", Unwin Paperbacks.	1983

Research Writing

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5205	Research Writing	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The primary objective of the course is to make one aware of the basics and structure of formal research writing. Emergent Writing using the Alphabetic Principle, Reading and Writing Through Language, Introducing punctuation, Collaborative writing, Metacognitive Regulations, Peer Interactions and Revision of Narratives, Making Digital Annotations, Structured Writing, Argumentative Writing, Instructive and Argumentative text, Teaching writing: Argumentative text and Oral presentations, Action Research, Writing "in your own words", Adapting to classroom setting, Composing a summary, Reflective thinking and writing.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	G.Rijlaarsdam, H.V. Den Bergh, M. Couzijn, "Effective Learning and Teaching of Writing", Kluwer Academic Publishers, Second Edition.	2005
	Reference Books	

2.	R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press.	2013
3.	M. Couzjin and G. Rijlaarsdam, "Learning to Red and Write Argumentative Text by Observation of Peer Learners", Kluwer Academic Publishers.	2005
4.	M. Cargil and P. O'Connor, "Writing Scientific Research Articles: Strategy and Steps", Second Edition, Wiley Blackwell	2013

Ethics and Human Values

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5207	Ethics and Human Values	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This couse contains topics of Course Introduction - Need, Basic Guidelines, Content an Process for Value Education, Understanding Harmony in the Human Being - Harmony in Myself, Understanding Harmony in the Family and Society - Harmony in Human-Human Relationship, Understanding Harmony in the Nature and Existence - Whole existence as Co-existence, Implications of the above Holistic Understanding of Harmony on Professional Ethics, Case studies of typical holistic technologies, management models and production systems.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	R. R. Gaur, R. Sangal, G. P. Bagaria, "A Foundation Course in Human Values and Professional Ethics", Excel Books.	2010
2.	E.G. Seebauer, R.L. Berry, "Fundamentals of Ethics for Scientists & Engineers", Oxford University Press.	2000
3.	M. Govindrajan, S. Natrajan & V. S. Senthil Kumar, "Professional Ethics and Human Values", PHI.	2013
	Reference Books	
4.	I. Illich, "Energy & Equity", The Trinity Press.	1974
5.	P. L. Dhar, R.R. Gaur, "Science and Humanism", Commonwealth Publishers.	1990
6.	A. N. Tripathy, "Human values", New Age International Publisher	2003

Engineering Economics

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5211	Engineering Economics	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

A primary goal of this course is to understand basic economic concepts and learn the role of science in economic concepts and learn the role of science in economic developement. Basic Concepts: demand, supply, elasticity of demand, production process and factors, market, monopoly, perfect competition and various cost concepts. Money, bank, tax and subsidy, monetary and fiscal policy, inflation and business cycle, international trade. Role of science engineering and technology in economic development: salient featrues of the Indian Economy, inclusive growth and relevance for the Indian Economy, Globalisation and opening up, GDP definition and its measurement, green revolution and white revolution, entrepreneurship, how environment has changed after advent of IT and Globalisation. interest formulas and their applications, calculations of economic equivalence.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	G. J. Thuesen & W. J. Fabrycky, Engineering Economy, Prentice- Hall of India Private Limited	2007
2.	W. G. Sullivan, J. A. Bontadelli & E. M. Wicks, Engineering Economy, Pearson Education Asia.	2009
	Reference Books	
3.	S. Singh, "Economics for Engineering Students", IK International Publishing House Pvt. Ltd.	2014
4.	D. G. Newman, J. P. Lavelle & T. G. Eschenbach, "Engineering Economic Analysis", Engineering Press.	2001

Business Communication and Presentation Skills

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5213	Business Communicational Presentation Skills	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

A primary goal of this course is to develop skills and competencies in students to be able to communicate effectively through the written and oral medium. The course includes basics of communication, the communication model, its barrier and facilitators, principles of effective communication and the 7 C's, effective communication and negotiation by learning the art of making effective presentations, meetings, interview, along with learning effective business communication and cross-cultural communication, formal writing and its importance, with various approaches to writing business letters, inquireies, claims, invitations etc. and report writing, along with non-verbal communication and its various types.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	R. V. Lesikar & J. D. Petit, "Basic Business Communication: Theory and Application", Tata McGraw Hill, Tenth Edition.	2007
2.	H.A. Murphy, W. Hildebrandt, J.P. Thomas, "Effective Business Communications", McGraw Hill, Seventh Edition.	2008
3.	J.V. Thill & C.L. Bovee, "Excellence in business communication", Pearson, Twelfth Edition.	2017
4.	L. Brown, "How to write anything", W.W. Norton and Company.	2014
	Reference Books	
5.	F. E. Dent & M. Brent, "Influencing: Skills and Techniques for Business Success", Palgrave Macmillan.	2006
6.	R. Ludlow & F. Panton, "The Essence of Effective Communications". Prentice Hall, New York.	1992

Communication Skills

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5215	Communication Skills	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The objective of the course is to impart essential skills required for effective communication in English languages. It includes basic introduction to communication as well as grammar and its usage. Photnetics of English, Vowels Consonants, syllables, transcription of words and simple sentences using IPA: Speech Sounds and their articulation; phonemes, Syllable, Stress, Transcription of words and Simple sentences. Composition- Descriptive, Explanatory, Analytical and Argumentative Writing Paragraphs (Essay, Summary, Abstract) Reading and Comprehension, Providing working mechanism of instruments, appliances, description of processes, their operations and descriptions; Drawing Ingerences from graphs, charts, Diagrams etc.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	V. N. Arora & L. Chandra, "Improve your Writing", Oxford University Press.	2013
2.	M. Raman, S. Sharma, "Technical Communication: Principles and Practice", Oxford University Press.	2014
3.	P. Roach, "English Phonetics and Phonology: A Practical Course:, Combridge University Press.	2014
	Reference Books	

4.	M. M. Maison, "Examine your English", Orient Blackswam.	2009
5.	S. Sharma & B. Sharma, "Communication Skills for Engineers & Scientists", PHI.	2012

Ethics and Technology

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5217	Ethics and Technology	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The goal of the course is to help students understnad the relations between ethics and technology. It includes introduction to ethics, morality, meta ethical theories, normative theories, ethical principles. Human Rights, Capital Punishment, Suicide, Euthanasia, Santhara, Female Feticide, Surrogacy, Feminism, Professional Ethics: Professionalism, Market/Busines Concerns Engineering Ethics, Engineering Case Studies. Industrial Revolution, Age of Information Technology, Social and Economic Implication.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	J. Rachel, "The Elements of Moral Philosophy", McGraw Hill.	2003
2.	N. Hartmann, "Moral Phenomena", New Macmillan.	1950
3.	R. Subramaniam, "Professional Ethics Includes Human Values", Oxford University Press.	2013
	Reference Books	
4.	Aristotle, "Nichomachian Ethics", Oxford University Press.	1926

University Elective II

Financial Data Analytics

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5202	Financial Data Analytics	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The objective of the course is to familiarize the students with the financial environment of business, especially the financial markets and acquaint them with accounting mechanics, process and system. Introduction to Management: Basic concepts of management, management process, principles of management, functions, levels managerial roles and skills. Introduction to Financial Environment and accounting: Financial Markets: Capital Markets, basics of capital market mechanism, intruments, financing and rating institutions. Importance, Objectives and Principles of Accounting, Accounting Concepts and conventions, and the Generally Accepted Accouting Principles (GAAP), Overview of Business Activities and Principal Finanncial Statements: Balance Sheet, Profit and Loss statement, cash flows. Overview of the Accounting Process. Distinction between cash profits and book profits. Understnading the cash flow statement and the funds flow statement. Importance, objectives and concept of Ratio Analysis-Liquidity, leverage, solvency and profitability ratios.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	S. P. Robbins, D.A. De Cenzo, M. Controller, "Fundamental of Management", Pearson Education.	2011
2.	T.S. Grewal, "Introduction to Accountancy", S. Chand and Company (P) Ltd., Tenth Edition.	2009
3.	W. A. Stice, J. Stice, "Financial Accounting Reporting & Analysis", Cengage Learning, Seventh Edition.	2010
	Reference Books	
4.	S.N. Maheswari, S.K. Maheshwari, Financial Accounting, Vikas Publication, Fourth Edition.	2005
5.	M. C. Shukla, T. S. Grewal, S.C. Gupta, "Advance Accounts", S. Chand and Company (P) Ltd.	1997

Technical Report Writing

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5204	Technical Report Writing	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This course contains topics of Introduction to Technical Communication; Understanding Ethical and Legal Considerations, Writing Technical Documents, Writing Collaboratively. Technical Report and Papers: Analyzing Your Audience and Purpose, Researching Your Sbject, Organizing Your Information, IEEE technical writing, references. Writing Skills : Communicating Persuasively, Emphasizing Important Information, Writing Correct and Effective Sentences, Creating Graphics. LaTex Tutorial: Introduction to LaTex, Document Structure, Mathematical Typesetting, Spacing, font styles, Tables, Arrays, and Lists, equations, text formatting, graphics

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	M. Market, "Technical Communication", McMillan.	2015
2.	M. Kolln, L. Gray, "Rhetorical Grammar: Grammatical Choices, Rheotrical Effects", Longman, Seventh Edition.	2012

Cost Management of Engineering Projects

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5206	Technical Report Writing	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This course aims to provide an introduction to cost scenario in engineering projects. Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standndard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector Just-in-time approch, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	A. A. Atkinson, R.D. Banker, R.S. Kaplan, S.M. Young, "Management and Cost Accounting", Pearson.	1996
2.	A.K. Bhattacharya, "Principles and Practices of Cost Accounting", PHI.	2004
3.	N. D. Vohra, "Quantitative Techniques in Management", Tate McGraw Hill.	2017

Business Analytics

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5208	Data Analytics	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The objective of the course is to expose students to techniques of data analytics for decision support. Introduction to Analytics and data mining, Organization/sources of data, Data quality issues, dealing with incomplete or missing data, data classification. Data Analytics, Descriptive analytics, Perscriptive analytics and Predictive analytics for decision support.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	S.C. Albright, W.L. Winston, "Business Analytics: Data Analysis and Decision Making", South western College Publishing, Fifth Edition.	2015
2.	P. Halady, "Business Analytics: An Applications Focus", PHI Learning.	2013

Intellectual Property Rights

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5210	Intellectual Property Rights	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This course contains topics of Introduction to IPR Overview & Importance IPR in India - Genesis and Development IPR in abroad Some Important examples of IPR Patents and their definition; granting; infringement; searching & filing, Copyrights, Trademarks, relationships between infair competition andintellectual property laws, Overview of Biotechnology and Intellectual Property Biotechnology Research and Intellectual Property Rights Management Licensing and Enforcing Intellectual Property Industrial Designs; biotechnology & research and rights managements; legal issues, enforcement; Case studies in IPR.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	T. M. Murray, M. J. Mehlman, "Encyclopedia of Ethical, Legal and Policy issues in Biotechnology", John Wiley & Sons.	2000

2.	A. Parulekar, S. D. Souza, "Indian Patents Law - Legal & Business Implications", Macmillan.	2006
	Reference Books	
3.	P. N. Cheremisionoff, R. P. Ouellette, R. M. Bartholomew, "Biotechnology Applications and Research", Technomic Publishing Co., Inc. USA.	1985
4.	D. Balasubramaniam, C.F.A. Brycee, K. Dharmalingam, J. Green and K. Jayaraman, "Concepts in Biotechnology", University Press.	2002
5.	P. Narayanan, "Law of Copyright and Industrial Designs", Eastern law House.	2010
6.	Bourgagaize, Jewell and Buiser, "Biotechnology: Demystifying the Concepts", Wesley Longman.	2000

Technical Communication

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5212	Technical Communication	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This course aims to introduce the basics and intricacies of technical communication, which are required for effective sharing of views and ideas. Understanding the Technical Communnication Environment, Understanding ethical and legal considerations, Writing technical documents, Writing in collaboration, Planning the document: Analyzing your audience and purpose, Researching your project, Organizing your information, Developing and testing the verbal and visual information: communicating persuasively, writing coherent documents, writing effective sentences, designing documents and web sites, creating graphics. Learning important applications: Writing correspondence, job applications materials, proposals, informational reports, lab repoorts, recommendation reports, making oral presentations, connecting with the public.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	M. Markel, "Technical Communication", Bedford/St. Martin's, Tenth Edition	2012

Logical Reasoning and Critical Thinking

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5214	Logical reasoning and critical thinking	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

The aim of the course is to develop logical and analytical skills in students. Deductive logic: Categorical Proposition, Categorical Syllogism, Syllogism, Syllogism in Ordinary Language, Symbolic Logic. Informal Fallacy. Inductive Logic: Subject matter of Inductive Logic, Significance of Probability in Inductive Reasoning, Probability and the Scientific Method, The Philosophical Problem of Induction. Mill's Experimental Methods: Method of Agreement, Method of Difference, Joint Method of agreement and Difference, Method of Concomitance Variation, Method of Residues.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	I.M. Copi, C. Cohen, K. McMohan, "Introduction to Logic", Tata Pearson, Fourteenth Edition.	2012
2.	I.M. Copi, "Symbolic Logic", Pearson.	2008
3.	C. Chakraborti, "Logic: Informal, Symbolic and Inductive", PHI.	2007
	Reference Books	
4.	I. Hacking, "An Introduction to Probability and Inductive Logic", Free Press.	1960
5.	W.V.O. Quine, "Methods of Logic", Routledge.	1965
6.	M. Sen, "Logic", Pearson.	2008

Multimedia Tools and Technology

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5216	Multimedia Tools and Technology	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: Computer Graphics, Web Technology

Details of Course

This course contains topics of Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. Audio and Speech, Images, Multimedia and Hypermedia, Hypermedia Presentation.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	T. Vaughan's "Multimedia: Making it work", Tata McGraw- Hill, Ninth Edition.	2017
	Reference Books	
2.	R. Aggarwal & B. B. Tiwari, "Multimedia Systems", Excel Publication.	2007
3.	Li & Drew, "Fundamentals of Multimedia", Pearson Education.	2009
4.	D. Hillman, "Multimedia Technology and Application", Galgotia Publication.	1998

Data Analytics

Teaching and Examination Scheme				Credits	Hours/ Week			Exam Duration (Hrs)		Relative Weights (%)				
Sem	Subject Code	Course Title	Type		L	T	P	TH	PR	CWS	MTE	ETE	PRS	PRE
	UEC-5218	Data Analytics	Elective	2	2	0	0	Yes	No	20	30	50	-	-

Pre-requisite: None

Details of Course

This course provides an introduction to data analytics and its various applications. Introduction to data analytics, Probability distributions, Model fitting, Descriptive statistics, Inferential Statistics through hypothesis tests. Supervised learning: Linea and logistic Regression, ANNOVA, Linear and quadratic discriminant analysis, K-nearest neighbors, neural networks, deep learning, support vector machines, decision trees, random forest. Unsupervised learning: K- means clustering, Hierarchical clustering, Unsupervised model fitting, Associative rule mining, Anomaly detection. Overview of information integration, integrated views and schema mapping, impact of increasing the number of data sources, data compression, record linking, data exchange, data fusion, data cleaning, source modeling, and information extraction Retrieving data from Big data management systems, processing on Hadoop and Spark. Prescriptive Analytics.

Suggested Readings :-

S. No.	Name of Books / Authors / Publishers	Years of Publications/ Reprint
	Text Books	
1.	T. Hastie, R. Tibshirani, J. Friedman, "The Elements of Statistical Learning: Data Mining, Inference, and Prediction", Springer, Second Edition.	2009
2.	A. Doan, A. Halevy, Z. Ives, "Principles of Data Integration", Morgan Kaufmann, First Edition.	2012
3.	D.C. Montgomery and G.C. Runger "Applied statistics and probability for engineers", John Wiley and Sons.	2010

HEALTH CENTRE

DTU has extended benefits of medical facilities of Directorate General of Health Services, Govt. of Delhi, to all of its employees including faculty and other staff. Under this facility employees avail OPD facilities at Delhi Heath Services dispensaries situated all over Delhi and avail indoor facilities in all Govt. and empaneled private Hospitals and pathological laboratories. Further, for benefits of day-boarding and hostellers, employees and residents of the Campus, University has established an in-house Health Center where two qualified general physician (one for 4 hours during 01 pm to 5 pm and one for 3 hours during 9 am to 12 pm), one dentist and one ophthalmologist are providing services for 2 hours all the six days a week. Additionally an Orthopaedician (1-3 pm: Mon. Wed and Fri), a Gynaecologist (1-4 pm: Tue and Thu) and a Psychiatrist (1-4 pm: Tue and Thu) also provide their services at university health centre. One sport medicine-cum-physiotherapy center has also been established in Health Center for 2 hours in all the six days.

Sr. No.	Name	Expert
1.	Dr. Ravi Bansal	General Physician
2.	Dr. Rajesh Singhai	General Physician
3.	Dr. Arpana Bansal	Eye Specialist
4.	Dr. Bharat Bhushan Sethi	Dentist
5.	Dr. Subodh Mor	Sports Medicine-cum-Physiotherapist (MPT)
6.	Dr. Dinesh Bansal	Orthopaedician
7.	Dr.Nishi Jha	Gynaecologist
8.	Dr. Gaurav Gupta	Psychiatrist

ANNEXURES

- Fee Structure
- Academic Calendar 2019-20
- Fee concession for economically weaker sections
- Financial Support to Students
- Ordinance relating to Maintenance of Discipline
- DTU Administration and Faculty
- Forms and Formats

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)
Shahbad Daulatpur,Main Bawana Road, Delhi-42

F.No. DTU/Reg/Notification/2017-18/4502 Dated: 21.01.2019

Notification

Subject: Annual Fee of all the programs for the students taking admission in the Academic Session 2019-20.

The Competent Authority has approved the Annual Fee structure of the following programs for the students taking admission in the Academic Session 2019-20 :-

A. Bachelor of Technology (B.Tech) (Full Time)
B. Bachelor of Technology (B.Tech) (Lateral Entry)
C. Bachelor of Technology (B.Tech) (Evening)
D. Bachelor of Design (B.Des)
E. Bachelor of Business Administration (BBA) & B.A Economics (H)
F. Ph.D (Full Time / Part Time)
G. Master of Technology (M.Tech) (Full Time)
H. Master of Technology (M.Tech) (Part Time)
I. Master of Business Administration (Full Time)
J. Executive MBA
K. DASA Students
L. International Students
M. Withdrawal Policy

(A). Bachelor of Technology (B.Tech) (Full Time)

S.No.	Particulars	Fee in AY2019-20 (in Rs.)	Fee in AY2020-21 (in Rs.)	Fee in AY2021-22 (in Rs.)	Fee in AY2022-23 (in Rs)
1.	Tuition Fee	99,500	1,14,500	1,30,500	1,40,300
2.	**Non Govt. Component**				
2.1	Student Welfare fee (Co-curricular Activities, Training & Placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, Outsourcing, conference, seminar, workshop, innovative projects, skill development activities and Misc. Expenditure on unspecified items)	20,000	20,000	20,000	20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	28,000	35,000	35,000	36,000
2.3	Economically weaker section fund	5,000	5,000	5,000	7,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.)	13,000	15,000	15,000	15,000
2.5	Premium amount for medi-claim of student (per annum)	500	500	500	700
	Total	**1,66,000**	**1,90,000**	**2,06,000**	**2,19,000**

(B). Bachelor of Technology (B.Tech) (Lateral Entry)

S.No.	Particulars	Fee in AY2019-20 (in Rs.)	Fee in AY2020-21 (in Rs.)	Fee in AY2021-22 (in Rs.)
1.	Tuition Fee	99,500	1,23,500	1,30,500
2.	**Non Govt. Component**			
2.1	Student Welfare fee (Co-curricular Activities, Training & Placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, Outsourcing, conference, seminar, workshop, innovative projects, skill development activities and Misc. Expenditure on unspecified items)	20,000	20,000	20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	28,000	28,000	35,000
2.3	Economically weaker section fund	5,000	5,000	5,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.)	13,000	13,000	15,000
2.5	Premium amount for medi-claim of student (per annum)	500	500	500
	Total	**1,66,000**	**1,90,000**	**2,06,000**

(C). Bachelor of Technology (B.Tech) (Evening)

S.No.	Particulars	Fee in AY2019-20 (in Rs.)	Fee in AY2020-21 (in Rs.)	Fee in AY2021-22 (in Rs.)	Fee in AY2022-23 (in Rs.)
1.	Tuition Fee	86,500	90,000	98,500	1,00,000
2.	**Non Govt. Component**				
2.1	Student Welfare fee (Co-curricular Activities, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, Outsourcing, conference, seminar, workshop, innovative projects, skill development activities and Misc. Expenditure on unspecified items)	16,000	16,000	16,000	16,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	16,000	21,000	21,000	21,000
2.3	Economically weaker section fund	500	500	500	500
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.)	11,000	12,000	12,000	12,000
2.5	Premium amount for medi-claim of student (per annum)	500	500	500	500
	Total	**1,30,500**	**1,40,000**	**1,48,500**	**1,50,000**

(D). Bachelor of Design (B.Des)

S.No.	Particulars	Fee in AY2019-20 (in Rs.)	Fee in AY2020-21 (in Rs.)	Fee in AY2021-22 (in Rs.)	Fee in AY2022-23 (in Rs)
1.	Tuition Fee	99,500	1,14,500	1,30,500	1,40,300
2.	**Non Govt. Component**				
2.1	Student Welfare fee (Co-curricular Activities, Training & Placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, Outsourcing, conference, seminar, workshop, innovative projects, skill development activities and Misc. Expenditure on unspecified items)	20,000	20,000	20,000	20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	28,000	35,000	35,000	36,000
2.3	Economically weaker section fund	5,000	5,000	5,000	7,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.)	13,000	15,000	15,000	15,000
2.5	Premium amount for medi-claim of student (per annum)	500	500	500	700
	Total	**1,66,000**	**1,90,000**	**2,06,000**	**2,19,000**

(E). Bachelor of Business Administration (BBA) & B.A Economics (H)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 (Rs.)	Fee in AY 2021-22 (Rs.)
1.	Tuition Fee	33,500	41,500	45,000
2.	**Non Govt. Component**			
2.1	Student Welfare Fee (Co-curricular activities, Training & placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, outsourcing, conference, seminar, workshop, innovative projects, skill development activities and, Misc. Expenditure on Unspecified Items)	15,000	15,000	15,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	15,000	15,000	15,000
2.3	Economically weaker section fund	5,000	5,000	5,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.	13,000	13,000	13,000
2.5	Premium amount for mediclaim of student (per-annum)	500	500	500
	GRAND TOTAL	**82,000**	**90,000**	**93,500**

(F). Ph.D (Full Time / Part Time)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 and onwards (Rs.)
1.	The academic staff of DTU DCE staff (R.19.1) and Project staff pursuing Ph.D as in R.19.11	15,000	5,000
2.	Other Full Time / Part Time candidates	25,000	10,000

(G). Master of Technology (M.Tech) (Full Time)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 (Rs.)
1.	Tuition Fee	1,05,500	1,05,000
2.	**Non Govt. Component**		
2.1	Student Welfare Fee (Co-curricular activities, Training & placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, outsourcing, conference, seminar, workshop, innovative projects, skill development activities and, Misc. Expenditure on Unspecified Items)	18,000	18,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	25,000	25,000
2.3	Economically weaker section fund	5,000	5,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.	12,000	12,000
2.5	Premium amount for mediclaim of student (per-annum)	500	500
	GRAND TOTAL	**1,66,000**	**1,66,000**

(H). Master of Technology (Part Time)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 (Rs.)	Fee in AY 2021-22 (Rs.)
1.	Tuition Fee	99,500	99,500	99,500
2.	**Non Govt. Component**			
2.1	Student Welfare Fee (Co-curricular activities, Training & placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, outsourcing, conference, seminar, workshop, innovative projects, skill development activities and, Misc. Expenditure on Unspecified Items)	20,000	20,000	20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	28,000	28,000	28,000
2.3	Economically weaker section fund	5,000	5,000	5,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.	13,000	13,000	13,000
2.5	Premium amount for mediclaim of student (per-annum)	500	500	500
	GRAND TOTAL	**1,66,000**	**1,66,000**	**1,66,000**

(I). Master of Business Administration (MBA) (Full Time)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 (Rs.)
1.	Tuition Fee	1,03,500	1,19,500
2.	**Non Govt. Component**		
2.1	Student Welfare Fee (Co-curricular activities, Training & placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, outsourcing, conference, seminar, workshop, innovative projects, skill development activities and, Misc. Expenditure on Unspecified Items)	20,000	20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	25,000	30,000
2.3	Economically weaker section fund	5,000	5,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.	12,000	15,000
2.5	Premium amount for mediclaim of student (per-annum)	500	500
	GRAND TOTAL	**1,66,000**	**1,90,000**

(J). Executive MBA (EMBA)

S.No.	Particulars	Fee in AY 2019-20 (Rs.)	Fee in AY 2020-21 (Rs.)
1.	Tuition Fee	1,70,000	1,75,000
2.	**Non Govt. Component**		
2.1	Student Welfare Fee (Co-curricular activities, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, outsourcing, conference, seminar, workshop, innovative projects, skill development activities and, Misc. Expenditure on Unspecified Items)	22,000	22,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	22,000	22,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.	12,000	12,000
2.5	Premium amount for mediclaim of student (per-annum)	500	500
	GRAND TOTAL	**2,26,500**	**2,31,500**

(K) DASA Students

S.No	Particulars	Fee in AY 2019-20	Fee in AY 2020-21	Fee in AY 2021-22	Fee in AY 2022-23
A. 1.	**Tuition Fee**				
	(a) Foreign Nationals except from SAARC and ASEAN countries	$ 8000	$ 8000	$ 8000	$ 8000
	(b) Foreign Nationals from SAARC and ASEAN Countries (The candidates from Nepal and Bhutan can submit their fees in equivalent Indian Rupees. However, they will be required to get Exchange Rate Certificate from the bankers and submit the same)	$ 4000	$ 4000	$ 4000	$ 4000
	(c) Children of Indians workers in Gulf Countries (CIWG) through DASA	Rs. 99,500	Rs. 1,14,500	Rs. 1,30,500	Rs. 1,40,300
2.	**Non Govt. Component for 1(a), 1(b) & 1 (c)**				
2.1	Student Welfare fee (Co-curricular Activities, Training & Placement, Extra Curricular Activities, Annual Gathering, Students welfare, Institutional Development, Outsourcing, conference, seminar, workshop, innovative projects, skill development activities and Misc. Expenditure on unspecified items)	Rs.20,000	Rs.20,000	Rs.20,000	Rs, 20,000
2.2	Facilities & Services Charges (Research initiatives, training programmes, Awards, automation, facilities, entrepreneurship activities and any misc. expenditure on unspecified items)	Rs.28,000	Rs.35,000	Rs.35,000	Rs, 36,000
2.3	Economically weaker section fund	Rs.5,000	Rs.5,000	Rs.5,000	Rs.7,000
2.4	Examination fee (Examination Infrastructure strengthening, expenditure on examination activities, confidential printing etc.)	Rs.13,000	Rs.15,000	Rs.15,000	Rs.15,000
2.5	Premium amount for medi-claim of student (per annum)	Rs.500	Rs.500	Rs. 500	Rs. 700
	Sub Total (2.1 to 2.5)	**Rs.66,500**	**Rs.75,500**	**Rs.75,500**	**Rs.78,700**
B.	**Grand Total (1 & 2) :**				
	(a) Foreign Nationals except from SAARC and ASEAN countries	$ 8000 + Rs. 66,500	$ 8000 + Rs.75,500	$ 8000 + Rs.75,500	$ 8000 + Rs.78,700
	(b) Foreign Nationals from SAARC and ASEAN Countries (The candidates from Nepal and Bhutan can submit their fees in equivalent Indian Rupees. However, they will be required to get Exchange Rate Certificate from the bankers and submit the same)	$ 4000 + Rs. 66,500	$ 4000 + Rs.75,500	$ 4000 + Rs.75,500	$ 4000 + Rs.78,700
	(c) Children of Indians working in Gulf Countries (CIWG) through DASA	**Rs. 1,66,000**	**Rs. 1,90,000**	**Rs. 2,06,000**	**Rs. 2,19,000**

(L) International Students

(i) Annual Tuition Fee for UG Students

S.No	Particulars	Fee in AY 2019-20	Fee in AY 2020-21	Fee in AY 2021-22	Fee in AY 2022-23
1.	Direct Admission for Foreign Nationals: Applications routed through Govt. of India agencies	USD 5000	USD 5000	USD 5000	USD 5000
	Foreign Nationals from SAARC and ASEAN Countries (routed through Govt. of India Agencies)	USD 2500	USD 2500	USD 2500	USD 2500
2.	Direct Admission for Foreign Nationals – Directly applied to DTU	USD 5000	USD 5000	USD 5000	USD 5000
	Foreign Nationals from SAARC and ASEAN Countries (directly applied to DTU)	USD 2500	USD 2500	USD 2500	USD 2500

(ii) Annual Tuition Fee for PG Students

S.No	Particulars	Fee in AY 2019-20	Fee in AY 2020-21
1.	Direct Admission for Foreign Nationals: Applications routed through Govt. of India agencies	USD 5000	USD 5000
	Foreign Nationals from SAARC and ASEAN Countries (routed through Govt. of India Agencies)	USD 2500	USD 2500
2.	Direct Admission for Foreign Nationals – Directly applied to DTU	USD 5000	USD 5000
	Foreign Nationals from SAARC and ASEAN Countries (directly applied to DTU)	USD 2500	USD 2500

(iii) Annual Tuition Fee for Ph.D Students

	Fee in AY 2019-20	Fee in AY 2020-21 and onwards
Ph.D	USD 2500	USD 1000

(M) Withdrawal Policy (For A to J)

S.No.	Percentage of Refund of aggregate fee *	Point of Time when Notice of withdrawal of admission is served to HEI
1.	100%	15 days before the formally notified last date of admission.
2.	80%	Not more than 15 days after the formally notified last date of admission
3.	50%	More than 15 days but less than 30 days after formally notified last date of admission.
4.	00%	More than 30 days after formally notified last date of admission.

***(Inclusive of Tuition fees and Non Govt. Component).**

Student permitted for semester/year withdrawal as per ordinance has to pay the fees for the semester/year for which he/she has been granted withdrawal. However, he/she will not be charged the fees when he/she is completing his/her semester/year.

This issues with the prior approval of the Competent Authority.

(Prof. Samsher)
Registrar

F.No. DTU/Reg/Notifications/2017-18/4503 Dated: 21.01.2019

Copy to the :

1. PA to VC for kind information of the Hon'ble Vice Chancellor.
2. PA to Pro VC (I) for kind information of the Pro Vice Chancellor
3. PA to Pro VC (II) for kind information of the Pro Vice Chancellor
4. All the Deans & Heads of the Academic Department of DTU
5. All Associate Deans/ Associate Heads
6. Controller of Examination
7. OSDs, East Delhi Campus, DTU.
8. All Branch In-charges
9. Head (Computer Center): with a request to upload on the University website.

(Prof. Samsher)
Registrar

ACADEMIC CALENDAR (2019-20)

ODD SEMESTER

26.04 2019 (Friday) – 13.05. 2019 (Monday)	Filling of online registration forms by all students for **UG**: III, V and VII Semester regular courses and /or back papers / improvements/re-registration as applicable including all Ex-Students. **PG**: III Semester regular /back papers as applicable including all Ex- students **PhD**: Continuing PhD students/scholars
01.08.2019 (Wednesday)	On campus registration in person by all UG and PG students, continuing PhD students/scholars & all Ex-Students (for back papers, improvements, re-registration). Teaching starts for UG: III, V and VII Semester courses; PG: III Semester courses.
01.08.2019 (Thursday)	Vice Chancellor's Address to newly admitted Students Orientation and on campus registration and Teaching starts from 02.08.2019 (Friday).
16.08.2019 (Friday)	Last date of registration of the courses, addition/deletion of courses for all regular and Ex- students (except those students whose admission is confirmed later to this date).
Supplementary Examination/Make up Examinations: 19th August 2019 (Monday) onward	
20.09.2019 (Friday)	Mid Term notification of shortage of attendance.
MID Semester Examination: 23rd Sept-28th Sept 2019 (Monday-Saturday) **MID Semester Break: 7th Oct-11th Oct, 2019 (Monday-Friday) Only for UG/PG students** **Notification of Make up for MID Semester Examination: 14th Oct-18th Oct 2019 (Monday-Friday)**	
20.11.2019 (Wed)	Teaching ends for all classes; Display of sessional marks and shortage of attendance
END Semester Theory & Practical Examination: 25.11.2019 (Monday) onwards	
16.12.2019 (Monday)	Grade moderation and display of grades for I, III and V semester (UG) courses.
17.12.2019 - 1.1.2020	**Winter Vacation**
30.12.2019 (Monday)	**Declaration of End semester results**

EVEN SEMESTER

26.12.2019(Thursday) -02.01.2020 (Thursday)	Filling of online registration forms by all UG, PG and Ph.D. students including Ex-Students (for back papers, improvements re-registration).
02.01.2020 (Thursday)	On campus registration in person by all students including Ex-Students (for back papers, improvements, re-registration) by submitting copy of online registration form & Teaching starts for all classes
17.01.2020 (Friday)	Last date of registration for all students, including Ex-students.
Supplementary /Makeup Examination: 13th Jan 2020 (Monday) onwards	
28.02.2020 (Friday)	Mid Term notification of shortage of attendance
MID Semester Examination 2nd March -7th March, 2020 (Monday-Saturday) **Mid Semester Break 9th March -13th March, 2020 (Monday-Friday)Only for UG/PG students** **Notification of Make up for MID Semester Examination: 23rd March-27th March, 2020 (Monday-Friday)**	
30.04.2020 (Thursday)	Teaching ends for all classes; Display of sessional marks and shortage of attendance
END Semester Theory & Practical Examination: 04.05.2020 (Monday) onwards	
29.05.2020 (Friday)	Grade moderation & display of grades for II,IV and VI semester (UG) courses.
08.06.2020 (Monday)	**Summer Vacation , Workshop Training, Industrial Training**
15.06.2020 (Monday)	**Declaration of End semester results except Major Project-II for PG program.**
20.07.2020 (Monday)	**University reopens after summer vacation**
Yuvaan Literary & Film Fest	23rd – 25th Jan, 2020 (Thursday to Saturday)
Technical Festival	7th – 9th Feb, 2020 (Friday to Sunday)
Engifest	14th – 16th Feb, 2020 (Friday to Sunday)
Sports Meet	21st – 23rd Feb, 2020 (Friday to Sunday)

FEE CONCESSION FOR STUDENTS BELONGING TO ECONOMICALLY WEAKER SECTIONS

All the desirous and eligible students of DTU who belongs to lower income group and wish to seek financial assistance for fee concession may submit the application online on www.btechstudentportal.dtu.ac.in (portal will be active in the month of August). The criteria and guidelines for the fee concession and concession in hostel fee are as under:-

1. The students whose family income from all sources is less than Rs. 4,50, 000/- per annum will only be eligible for fee concession. Income Certificate should be valid at the time of online application issued by SDM/1st Class Magistrate in case of others, ITR for previous financial year in case of Govt. Employee.

2. The students of 1st year and 3rd year shall deposit the University annual fee at the start of the academic session and fee concession amount will be reimbursed if he/she fulfills the criteria of fee concession. In 2nd and 4th year the student will deposit the fee as per the applicable fee concession received in 1st and 3rd year respectively.

3. First year student has to submit the copies of the all mark sheets starting from 12th class and JEE Rank Card.

4. Any student who availed fee concession in 1st year will continue to be eligible for Fee Concession in 2nd year also, similarly student availing fee concession in 3rd year will continueto be eligible for the same in 4thyear also provided he/she has acquired minimum required credits for promotion from from1st year to 2nd year /3rd year to 4th year respectively.

5. The student has to submit an undertaking duly counter signed by his/her parents on stamp paper of Rs. 10/- duly attested by public Notary that "he/she has not obtained or applied for any grant/ financial help for the same purpose from any other Ministry/ Govt. Department of India/ State, any Public/ Private Organization." The application of the candidate concealing the facts will automatically stand cancelled.

6. The student should not be involved in any indisciplianary activity (ies) in the University.

7. Copy (ies) of Death Certificate of earning parent(s).

8. Copy of award letter of Scholarship/fellowship if any, being awarded any Govt. or non-govt. organization.

9. Copy of student Bank Passbook mentioning IFSC and Bank A/C No.

10. The full fee concession may be given to the student's maximum upto five (05) % of the sanctioned intake for the particular year in the respective program or equivalent to the number of double, the half fee concession may be granted to the deserving students.

11. The full fee concession will be granted to the wards (up to two children only) of all the Group C' employees and half fee concession may be granted to the wards (up to two children only) of all the "Group B' employees of the DTU/ DCE over and above the student's maximum upto five (05) % of the sanctioned intake for the particular year.

All shortlisted students will be required to appear for personal interview by a designated Committee for which dates will be announced later on. Applications will be accepted only through online portal, hand written applications will not be accepted.

FINANCIAL SUPPORT TO STUDENTS

Merit scholarship to the toppers of each branch of Bachelor of Technology.

The merit Scholarship is awarded strictly on principle of academic merit of the candidates who satisfy the following conditions:

1. Merit scholarship shall be given only to the toppers of all branches of B Tech program (F/T) annually with the condition that the student concerned has secured 75% or above as aggregate marks or CGPA =7.5 in an academic year.
2. The student who has passed all the subject of the semester in one attempt.
3. The student should have a sound moral character and should not have indulged into any act of misconduct during his/her studies at the University.
4. In case of tie, all awardees will be given Rs 5000/- each.

Approval accorded during 11th meeting of Academic Council held on 24.06.2015 and confirmed by BOM vide minutes of 17th BOM, DTU held on 17.07.2015.

Financial Assistance to students for presenting Research Paper/Poster in National/ International Conference /Events

This scheme is aimed at promoting research and development activities in various areas of professional education in an academic department by providing opportunity to students to interact at national and international level to update with the global changes in the concerned fields / area of specialisation.

Financial Assistance for Students' Innovative Projects

To strengthen the student innovative projects and to facilitate student teams venturing for innovative projects, there is a provision for financial support for which approval is accorded during 19th meeting of Academic Council held on 16.11.2018 and confirmed by BOM vide minutes of 29th BOM, DTU held on 30.11.2018.

Financial assistance for students for attending internship overseas

The scheme for financial assistance to students for attending internship overseas has been instituted keeping in view the importance of state of the art research and international exposure to students for which approval is accorded during 19th meeting of Academic Council held on 16.11.2018 and confirmed by BOM vide minutes of 29th BOM, DTU held on 30.11.2018.

ORDINANCE-6
(Maintenance of Discipline)

No. F. DTU/ORG/Notification/04(1)/2009..... In exercise of the powers conferred by sub-section (2) of Section 32 of the Delhi Technological University Act, 2009 (Delhi Act 6 of 2009), the Board of Management, Delhi Technological University, hereby makes Ordinanace-6 Maintenance of Discipline among students.

1. Short title and Commencement:

(a) These Ordinance may be called the Delhi Technological University (Sixth) Ordinance, 2012.

(b) They shall come into force with effect from the date of meeting of the Board of Management i.e. 28.12.2010

2. Definitions:

(i). In these ordinances, unless the context otherwise requires:-

(a). "Act", "statutes", "ordinance" and "regulations" mean respectively the Delhi Technological University Act, 2009 (6 of 2009), the statues, the ordinance and the regulations of the Delhi Technological University.

(b). "Department", and "School" means the academic departments and schools of Delhi Technological University.

(ii). Words and expression used, but not defined, in these ordinances shall have the meanings assigned to them in the Act and the statues.

3. Power to vest in the Vice Chancellor

(i). All powers relating to maintenance and enforcement of discipline among and disciplinary action against the students of the University shall vest in the Vice Chancellor.

(ii). The Vice Chancellor may delegate all or any such of his powers, as he deems proper, to such other officers and authorities of the university as he may specify in this behalf.

4. Acts of indiscipline and misconduct

1. Without prejudice to the generality of the power to maintain and enforce discipline under this ordinance, the following shall amount to acts of indiscipline or misconduct on the part of a student of the University:-

(a) Physical assault, or threat to use physical force, against any member of the teaching or non-teaching staff of any Department or school of the University or against any student or the University.

(b) Remaining or co-curricular activity which he/ she is expected to participate in;

(c) Carrying of, use of or threat to use, any weapon:

(d) Misbehavior, using abusive language or cruelty towards any other student, teacher or any other employee of the University.

(e) Use of drugs or other intoxicants except those prescribed by a qualified doctor;

(f) Any violation of the provisions of the Civil Rights Protection Act, 1976;

(g) Indulging in or encouraging violence or any conduct which involves moral turpitude;

(h) Any form of gambling;

(i) Violation of the status, dignity and honour of a student belonging to a scheduled caste or a schedule tribe.

(j) Discrimination against any student or a member of staff on grounds of caste, creed, language, place of origin, social and cultural background or any of them.

(k) Practicing casteism and untouchability in any form or inciting any other person to do so;

(l) Any act or gesture, whether verbal physical or otherwise verbal physical or otherwise,

derogatory to women;

(m) Consuming tobacco, liquor or smoking;

(n) Any attempt at bribing or corruption of any manner or description;

(o) Willful destruction of the property of the University.

(p) Behaving in a rowdy, intemperate or discovery manner in the premises of the University or encouraging or inciting any other person to do so;

(q) Causing disruption of any manner or description of the academic functioning of the University system;

(r) Indulging in or encouraging any form of disruptive activity connected with tests, examinations or any other activity of the University.

(s) Indulging in or encouraging any form of disruptive activity connected with tests, examinations or any other activity of the University;

(t) (Truancy and unpunctuality;

2. The Vice Chancellor may amend or add to the list of malpractices under clauses (1)

5. Penalties for breach of discipline

Without prejudice to the generality of his powers relating to the maintenance of discipline and taking such action in the interest of maintaining discipline as deemed appropriate by him.

(1) The Vice Chancellor may in exercise of his powers aforesaid, order or direct that any student or students-

(a) Be expelled from the University in which case he/ she shall not be re-admitted to the University, from where his expelled; or

(b) Be, for a stated period, rusticated in which case he/ she not be admitted to the University till the expiry of the period of rustication; or

(c) Be, for a stated period expelled from the University Hostel/ hall of residence or;

(d) Be not, for a stated period, admitted to a course or courses of study of the University; or

(e) Be imposed with the fine of a specified amount of money;

(f) Be debarred from taking a University examination or examinations for one or more years.

(2) The Vice Chancellor, in exercise of his powers aforesaid or on the recommendations of Board of Discipline, may also order or direct that the result of the student concerned of the examination or examinations at which he/ she has appeared, be canceller.

(3) The Chairman, Board of Discipline, Head of Teaching Departments and schools, Wardens of different hostels, Librarian and In-charge of any centralized facilities in the university shall have the authority to exercise disciplinary powers over students in their respective domain, in the university as may be necessary for the proper functioning of the department, hostel, library, central facility, which may include issuing warning, suspension from the classes/ hostels and/ or debarring from using the central facilities for a maximum period of one month. However, in all such cases, the final decision shall be taken by the Board of Discipline.

6. Ragging

Ragging for the purpose of this ordinance, shall ordinarily mean any act, conduct or practice by which the dominant power or status of senior students if brought to bear upon the students who are in any way considered junior or inferior by the former and includes individual or collective acts or practices which:

(a) Involve physical assault or threat to use physical force;

(b) Violate the status, dignity and honour of students, in particular woman/ girl students and those belonging to a schedules caste or a schedules tribe;

(c) Expose students to ridicule or contempt or commit an act which may lower their self esteem; and

(d) Entail verbal abuse, mental or physical torture, aggression, corporal punishment, harassment, trauma, indecent gesture and obscene behavior.

A. What constitutes Ragging?

Ragging constitutes one or more of the following acts:

(a) Any conduct by any students whether by words spoken or written or by an act which has the effect of teasing, treating or handling with rugnesses a fresher or any other students;

(b) Indulging in rowdy or indisciplined activities by any student or students which causes or is likely to cause annoyance, hardship, physical or psychological harm or to raise fear or apprehension thereof in any fresher or any other student;

(c) Asking any student to do any act which such student will it in the ordinary course do and which has the effect of causing or generating a sense of shame, or torment or embarrassment so as to adversely affect the physique or psyche of such fresher or any other student;

(d) Any act by a senior student that prevents, disrupts or disturbs the regular academic activity of any other student or a fresher;

(e) Exploiting the services of a fresher or nay other student for completing he academic tasks assigned to an individual or a group of students;

(f) Any act of financial extortion or forceful expenditure burden put on a fresher of any other student by students;

(g) Any act of physical abuse including all variants of it: sexual abuse, homosexual assaults, stripping, forcing obscene and lewd acts, gestures causing bodily harm or any other danger to health or person;

(h) Any act or abuse by spoken words, emails, post, public insults which would also include deriving perverted pleasure, vicarious or sadistic thrill from actively or passively participating in the discomfiture to fresher or any other student;

(i) Any act that affects the mental health or self-confidential of a fresher or any other student with or without an intent to derive a sadistic pleasure or showing off power, authority or superiority by a student over any fresher or any other student.

B. Prohibition of Ragging

(a) Ragging in any form is strictly prohibited in University campus and any part of University system, as well as on public transport or at any place, public or private.

(b) Any individual or collective act or practices of ragging constitutes gross indiscipline and shall be dealt with relevant provisions.

(c) The Head of the Department/ school, Proctor, wardens of Hostels, Librarian, In-charge of any central facility, security officer or any faculty member of the university shall take immediate action on receipt of any information of the occurrence of ragging.

(d) Notwithstanding anything in clause (iii) above, the Chairman, Board of Discipline may also suo-moto enquire into, any incident of ragging and make a report to the Vice Chancellor of the identity of those who have engaged in ragging and the nature of the incident.

(e) The Chairman, Board of Discipline may also submit an initial report to VC establishing the identity of the perpetrators, of ragging and the nature of the ragging incident.

(f) If the Head of the Department/ Schools, Proctor, Chief Warden, Librarian, In-charge-Central Facility and Chairman, Board of Discipline is satisfied that for some reason, to be recorded in writing, it is not feasible to hold such an enquiry, he/ she may so advice the Vice Chancellor accordingly.

(g) When the Vice Chancellor is satisfied that it is not expedient to hold such an enquiry into an incident of ragging, his/ her decision shall be final.

(h) One the receipt of a report under clause (iv) of (v) or determination by the relevant authority under clause (vi) disclosing the occurrence of ragging incidents described in clause 5 (A), the Vice Chancellor shall take appropriate penal action which may include rustication of a student or student for a specific number of year from University, debarring from appearing in University examination and/ or take any other measure as prescribed by Hon'ble Supreme Court or any Court of Law.

(i) The Vice Chancellor may in other cases of ragging order or direct that nay student or students be expelled or be not for a stated period admitted to a course of study or in a University Examination, for one or more years or that the result of student/ students concerned in the examination in which they appeared be cancelled.

(j) In case any students who have obtained degrees of Delhi Technological University are found guilty under this Ordinance, appropriate action for withdrawal of degrees conferred by the University shall be initiated.

(k) For the purpose of this Ordinance, abetment to ragging whether by way of any act, practice or incitement of ragging will also amount to ragging.

(l) All students shall be required to submit written undertaking(s) to the University in the beginning of academic session that they shall indulge into any act of ragging.

7. Declaration to be signed by a student

At the time of admission, every student shall be required to sign a declaration

On oath that he/ she shall submit himself/ herself to the disciplinary jurisdiction of the Vice Chancellor and other authorities of the University.

8. Constitution of the Board of Discipline

(1) The Boards of Discipline at the level of the University shall be constituted by the Vice Chancellor as follows:-

(a) A Professor of the University to be nominated by the Vice Chancellor – Chairman

(b) Chief Warden of the University Hostels

(c) Two senior teachers of the University to be nominated by the Vice Chancellor, members.

(d) One senior lady teacher of the University to be nominated by the Vice-Chancellor, member.

(e) Head of the concerned department/ school and hostel warden to which the act of indiscipline of misconduct by a student or students pertains to the Chairman in case feels that input from the student(s) are required for better examination of a case may do so by calling the student(s).

(f) Assistant Registrar (Academic) shall be the Member Secretary of the Board of Discipline.

(2) The members of the board including Chairman shall hold office for a period of two years and a vacancy occurring in the Board of Discipline shall be filled for the remaining period of the term of the member whose department has caused the vacancy.

(3) Three members of the Board of discipline including the Chairman, shall form the quorum.

(4) In the absence of the Chairman, the senior most member of the Board of Discipline shall act as the Chairman.

9. Functions of the Board of Discipline

(1) The Board of Discipline shall perform the following functions;-

(a) To consider matters concerning maintenance of discipline among the students in the University.

(b) To enquiry into the acts of indiscipline or misconduct committed by a student or students whenever such cases are referred to the Board of Discipline and to submit their findings conclusions and recommendations for the quantum of punishment under the provision of this ordinance to the Vice Chancellor or the person authorized by the Vice Chancellor in this behalf.

(c) To supervise and monitor the disciplinary climate prevailing in the University.

(d) To take preventative and precautionary steps such as issue of notices, warning, instructions etc. as the case may be, for the purpose of forestalling acts of individual or collective indiscipline, misconduct and ragging etc.

(e) To maintain liaison with the police authorities and the concerned departments of the Government, neighbouring institutions and the concerned authorities of the University regarding maintenance of law Chancellor from time to time.

(2) The decision in each case shall be conveyed by the Chairman communicating the penalty or penalties, if any, imposed on a student or students.

(3) A student or students, who are aggrieved with the penalty imposed upon them, may appeal to the vice chancellor whose decision in this regard shall be final and binding upon the parties.

DELHI TECHNOLOGICAL UNIVERSITY ADMINISTRATION

S. No.	NAME	DESIGNATION
1.	PROF. YOGESH SINGH	VICE CHANCELLOR
2.	PROF. S.K GARG	PRO-VICE CHANCELLOR
4.	PROF. SAMSHER	REGISTRAR
5.	SH. KAMAL PATHAK	CONTROLLER OF EXAMINATIONS
6.	DR. R.K SHUKLA	LIBRARIAN

DEANS

S. No.	NAME	DESIGNATION
1.	PROF. SURESH C. SHARMA	DEAN ACADEMICS (PG)
2.	PROF. MADHUSUDAN SINGH	DEAN ACADEMICS (UG)
3.	PROF. S. INDU	DEAN STUDENT WELFARE
4.	PROF. ASHUTOSH TRIVEDI	DEAN INDUSTRIAL RESEARCH DEVELOPMENT
5.	PROF. VISHAL VERMA	DEAN INTERNATIONAL AFFAIRS
6.	PROF. PRAVIR KUMAR	DEAN ALUMNI AFFAIRS
7.	PROF. R. S. MISHRA	DEAN , OUTREACH & EXTENSION ACTIVITIES
8.	PROF. SAMSHER	DEAN CONTINUING EDUCATION
9.	PROF. NARENDRA KUMAR	DEAN DISCIPLINE

HEAD OF THE DEPARTMENTS

S. NO.	NAME	DEPARTMENT
1.	PROF. S. G. WARKER	APPLIED CHEMISTRY
2.	PROF. RINKU SHARMA	APPLIED PHYSICS
3.	PROF. SANGITA KANSAL	APPLIED MATHEMATICS
4.	PROF. JAI GOPAL SHARMA	BIO TECHNOLOGY
5.	PROF. RAJNI JINDAL	COMPUTER SCIENCE & ENGINEERING
6.	PROF. NIRENDRA DEV	CIVIL ENGINEERING
7.	PROF. UMA NANGIA	ELECTRICAL ENGINEERING
8.	PROF. N. S. RAGHAV	ELECTRONICS AND COMMUNICATION ENGG
9.	PROF. S.K.SINGH	ENVIRONMENTAL ENGINEERING
10.	DR. NAND KUMAR	HUMANITIES
11.	PROF. KAPIL SHARMA	INFORMATION TECHNOLOGY
12.	PROF. VIPIN	MECHANICAL ENGINEERING
13.	PROF. RAJESH ROHILLA	TRAINING & PLACEMENT
14.	PROF. M.S.RANGANATH	DESIGN
15	PROF. RAJAN YADAV	DELHI SCHOOL OF MANAGEMENT
16.	PROF. AMIT MOOKARJEE	UNIVESTIY SCHOOL OF MANAGEMENT AND ENTREPRENURESHIP

LIST OF FACULTY

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
1.	APPLIED CHEMISTRY	DR. DEVENDRA KUMAR	PROFESSOR
2.	APPLIED CHEMISTRY	DR. ARCHNA RANI	PROFESSOR
3.	APPLIED CHEMISTRY	DR. SUDHIR GOPALRAO WARKER	PROFESSOR
4.	APPLIED CHEMISTRY	DR.R.C.SHARMA	PROFESSOR
5.	APPLIED CHEMISTRY	Dr. RAM SINGH	ASSOCIATE PROFESSOR
6.	APPLIED CHEMISTRY	Dr. ANIL KUMAR	ASSOCIATE PROFESSOR
7.	APPLIED CHEMISTRY	Dr. ROLI PURWAR	ASSOCIATE PROFESSOR
8.	APPLIED CHEMISTRY	Dr. RAMINDER KAUR	ASSISTANT PROFESSOR
9.	APPLIED CHEMISTRY	Sh. MANISH JAIN	ASSISTANT PROFESSOR
10.	APPLIED CHEMISTRY	MS. POONAM	ASSISTANT PROFESSOR
11.	APPLIED CHEMISTRY	Dr.SAURABH MEHTA	ASSISTANT PROFESSOR
12.	APPLIED CHEMISTRY	Dr. RICHA SRIVASTAVA	ASSISTANT PROFESSOR
13.	APPLIED CHEMISTRY	Dr. DEENAN SANTHIYA	ASSISTANT PROFESSOR
14.	APPLIED PHYSICS	DR. RAVINDRA KUMAR SINHA (ON LIEN)	PROFESSOR
15.	APPLIED PHYSICS	DR. SURESH CHAND SHARMA	PROFESSOR
16.	APPLIED PHYSICS	DR.RINKU SHARMA	PROFESSOR
17.	APPLIED PHYSICS	DR.ALLAM SRINIVASA RAO	PROFESSOR
18.	APPLIED PHYSICS	DR. VINOD SINGH	ASSOCIATE PROFESSOR
19.	APPLIED PHYSICS	DR. RISHU CHAUJJAR	ASSOCIATE PROFESSOR
20.	APPLIED PHYSICS	DR. NITIN KUMAR PURI	ASSOCIATE PROFESSOR
21.	APPLIED PHYSICS	DR. AJEET KUMAR	ASSISTANT PROFESSOR
22.	APPLIED PHYSICS	DR. AMRISH KUMAR PANWAR	ASSISTANT PROFESSOR
23.	APPLIED PHYSICS	DR. M.JAYASIMHADARI	ASSISTANT PROFESSOR
24.	APPLIED PHYSICS	DR. RENUKA BAKOLIA	ASSISTANT PROFESSOR
25.	APPLIED PHYSICS	DR.RICHA SHARMA	ASSISTANT PROFESSOR
26.	APPLIED PHYSICS	SH.YOGENDER KUM. MEENA	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
27.	APPLIED PHYSICS	DR. YOGITA KALRA	ASSISTANT PROFESSOR
28.	APPLIED PHYSICS	DR. MOHAN SINGH MEHATA	ASSISTANT PROFESSOR
29.	APPLIED PHYSICS	DR. PAWAN KUMAR TYAGI (On Lien)	ASSISTANT PROFESSOR
30.	APPLIED PHYSICS	DR. BHARTI SINGH	ASSISTANT PROFESSOR
31.	APPLIED PHYSICS	DR.SARITA BAGHEL	ASSISTANT PROFESSOR
32.	APPLIED PHYSICS	SH. DESHRAJ MEENA	ASSISTANT PROFESSOR
33.	APPLIED PHYSICS	DR. MUKHTIYAR SINGH	ASSISTANT PROFESSOR
34.	APPLIED MATHEMATICS	DR. H.C.TANEJA	PROFESSOR
35.	APPLIED MATHEMATICS	DR. SANGITA KANSAL	PROFESSOR
36.	APPLIED MATHEMATICS	DR. L.N.DAS	PROFESSOR
37.	APPLIED MATHEMATICS	DR.ANJANA GUPTA	PROFESSOR
38.	APPLIED MATHEMATICS	DR. RAMESH SRIVASTAVA	PROFESSOR
39.	APPLIED MATHEMATICS	DR.NAOKANT DEO	PROFESSOR
40.	APPLIED MATHEMATICS	DR. S.SIVAPRASAD KUMAR	PROFESSOR
41.	APPLIED MATHEMATICS	DR. V.P KAUSHIK	PROFESSOR
42.	APPLIED MATHEMATICS	DR. CHANDRA PRAKASH	ASSOCIATE PROFESSOR
43.	APPLIED MATHEMATICS	DR. ADITYA KAUSHIK	ASSOCIATE PROFESSOR
44.	APPLIED MATHEMATICS	DR. VIVEK KUMAR AGARWAL	ASSISTANT PROFESSOR
45.	APPLIED MATHEMATICS	DR. NILAM	ASSISTANT PROFESSOR
46.	APPLIED MATHEMATICS	SH. ROHIT KUMAR	ASSISTANT PROFESSOR
47.	APPLIED MATHEMATICS	MS. GOONJAN JAIN	ASSISTANT PROFESSOR
48.	APPLIED MATHEMATICS	DR. DINESH UDAR	ASSISTANT PROFESSOR
49.	APPLIED MATHEMATICS	MS. SUMEDHA SENIARAY	ASSISTANT PROFESSOR
50.	APPLIED MATHEMATICS	MS. TRASHA GUPTA	ASSISTANT PROFESSOR
51.	APPLIED MATHEMATICS	Ms. PAYAL	ASSISTANT PROFESSOR
52.	APPLIED MATHEMATICS	SH. ANSHUL ARORA	ASSISTANT PROFESSOR
53.	APPLIED MATHEMATICS	SH.DHIRENDRA KUMAR	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
54.	APPLIED MATHEMATICS	SH. JAKHONGAM TOUTHANG	ASSISTANT PROFESSOR
55.	BIOTECHNOLOGY	DR. PRAVIR KUMAR	PROFESSOR
56.	BIOTECHNOLOGY	DR. JAI GOPAL SHARMA	PROFESSOR
57.	BIOTECHNOLOGY	DR. YASHA HASIJA	ASSOCIATE PROFESSOR
58.	BIOTECHNOLOGY	DR. NIRALA RAMCHIARY	ASSOCIATE PROFESSOR
59.	BIOTECHNOLOGY	DR. ASMITA DAS	ASSISTANT PROFESSOR
60.	BIOTECHNOLOGY	DR. NAVNEETA BHARDWAJ	ASSISTANT PROFESSOR
61.	CIVIL ENGG.	DR. V.K.MINOCHA	PROFESSOR
62.	CIVIL ENGG.	DR.S.K.SINGH	PROFESSOR
63.	CIVIL ENGG.	DR.ASHUTOSH TRIVEDI	PROFESSOR
64.	CIVIL ENGG.	DR. ASHOK KUMAR GUPTA	PROFESSOR
65.	CIVIL ENGG.	DR. NIRENDER DEV	PROFESSOR
66.	CIVIL ENGG.	DR. K.C.TIWARI	PROFESSOR
67.	CIVIL ENGG.	DR.ANIL KUMAR SAHU	PROFESSOR
68.	CIVIL ENGG.	DR. RAKESH KUMAR	PROFESSOR
69.	CIVIL ENGG.	DR.ALOK VERMA	PROFESSOR
70.	CIVIL ENGG.	DR. NARESH KUMAR	PROFESSOR
71.	CIVIL ENGG.	DR.AMIT KUMAR SRIVASTAVA	PROFESSOR
72.	CIVIL ENGG.	DR. AWADHESH KUMAR	PROFESSOR
73.	CIVIL ENGG.	MR. G.P.AWADHIYA	ASSOCIATE PROFESSOR
74.	CIVIL ENGG.	DR.S.ANBU KUMAR	ASSOCIATE PROFESSOR
75.	CIVIL ENGG.	MR.NARAD MUNI PRASAD	ASSOCIATE PROFESSOR
76.	CIVIL ENGG.	DR.SUSHEEL KUMAR	ASSOCIATE PROFESSOR
77.	CIVIL ENGG.	DR. MUNENDER KUMAR	ASSOCIATE PROFESSOR
78.	CIVIL ENGG.	DR. T.VIJAY KUMAR	ASSOCIATE PROFESSOR
79.	CIVIL ENGG.	DR. RAJU SARKAR (on lien)	ASSOCIATE PROFESSOR
80.	CIVIL ENGG.	MR. A.R.KONGAN	ASSOCIATE PROFESSOR
81.	CIVIL ENGG.	Dr. SHILPA PAL	ASSOCIATE PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
82.	CIVIL ENGG.	DR. PARDEEP KUMAR GOYAL	ASSOCIATE PROFESSOR
83.	CIVIL ENGG.	MR.B.R.G.ROBERT	ASSISTANT PROFESSOR
84.	CIVIL ENGG.	DR. BHARAT JHAMNANI	ASSISTANT PROFESSOR
85.	CIVIL ENGG.	SH. HARIKESH DUBEY	ASSISTANT PROFESSOR
86.	CIVIL ENGG.	DR. RITURAJ	ASSISTANT PROFESSOR
87.	COMPUTER SCI. & ENGG.	DR. RAJINI JINDAL	PROFESSOR
88.	COMPUTER SCI. & ENGG.	DR DAYA GUPTA	PROFESSOR
89.	COMPUTER SCI. & ENGG.	MR. VINOD KUMAR	ASSOCIATE PROFESSOR
90.	COMPUTER SCI. & ENGG.	MR. MANOJ KUMAR	ASSOCIATE PROFESSOR
91.	COMPUTER SCI. & ENGG.	Dr. RAHUL KATARYA	ASSOCIATE PROFESSOR
92.	COMPUTER SCI. & ENGG.	Dr. ANIL SINGH PARIHAR	ASSOCIATE PROFESSOR
93.	COMPUTER SCI. & ENGG.	DR. ARUNA BHATT	ASSOCIATE PROFESSOR
94.	COMPUTER SCI. & ENGG	DR. RUCHIKA MALHOTRA	ASS0CIATE PROFESSOR
95.	COMPUTER SCI. & ENGG	DR. SHAILENDER KUMAR	ASSOCIATE PROFESSOR
96.	COMPUTER SCI. & ENGG.	DR. AKSHI KUMAR	ASSISTANT PROFESSOR
97.	COMPUTER SCI. & ENGG.	DR. RAJESH KUMAR YADAV	ASSISTANT PROFESSOR
98.	COMPUTER SCI. & ENGG.	MR. ROHIT BENIWAL	ASSISTANT PROFESSOR
99.	COMPUTER SCI. & ENGG.	MR.NIPUN BANSAL	ASSISTANT PROFESSOR
100.	COMPUTER SCI. & ENGG.	MS.MINNI JAIN	ASSISTANT PROFESSOR
101.	COMPUTER SCI. & ENGG.	MR. SANJAY KUMAR	ASSISTANT PROFESSOR
102.	COMPUTER SCI. & ENGG.	MR. PRASHANT GIRIDHAR SHAMBHARKAR	ASSISTANT PROFESSOR
103.	COMPUTER SCI. & ENGG.	MS. ABHILASHA SHARMA	ASSISTANT PROFESSOR
104.	COMPUTER SCI. & ENGG.	DR.DIVYASHIKHA SETHIA	ASSISTANT PROFESSOR
105.	COMPUTER SCI. & ENGG.	MR. SANJAY PATIDAR	ASSISTANT PROFESSOR
106.	COMPUTER SCI. & ENGG.	MS. SONIKA DAHIYA	ASSISTANT PROFESSOR
107.	COMPUTER SCI. & ENGG	MR. RAHUL	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
108.	ELECTRONICS AND COMM. ENGG.	DR. ASOK DE	PROFESSOR
109.	ELECTRONICS AND COMM. ENGG.	DR. RAJIV KAPOOR	PROFESSOR
110.	ELECTRONICS AND COMM. ENGG.	DR.O.P. VERMA (DIVERTED CAPACITY AT G.B.PANT ENGG. COLLEGE W.E.F 19.04.2017)	PROFESSOR
111.	ELECTRONICS AND COMM. ENGG.	DR. N.S.RAGHAVA	PROFESSOR
112.	ELECTRONICS AND COMM. ENGG.	DR. S.INDU	PROFESSOR
113.	ELECTRONICS AND COMM. ENGG.	DR. NEETA PANDEY	PROFESSOR
114.	ELECTRONICS AND COMM. ENGG.	DR. RAJESHWARI PANDEY	PROFESSOR
115.	ELECTRONICS AND COMM. ENGG.	DR. DINESH KUMAR	PROFESSOR
116.	ELECTRONICS AND COMM. ENGG.	DR. JEEBANANDA PANDA	PROFESSOR
117.	ELECTRONICS AND COMM. ENGG.	DR. RAJESH ROHILLA	PROFESSOR
118.	ELECTRONICS AND COMM. ENGG.	DR. D.R. BHASKAR	PROFESSOR
119.	ELECTRONICS AND COMM. ENGG.	Dr. ALOK KUMAR SINGH	ASSOCIATE PROFESSOR
120.	ELECTRONICS AND COMM. ENGG.	DR. MAHIPAL SINGH CHOUDHARY	ASSOCIATE PROFESSOR
121.	ELECTRONICS AND COMM. ENGG.	MR. RAJESH BIROK	ASSOCIATE PROFESSOR
122.	ELECTRONICS AND COMM. ENGG.	DR. POORNIMA MITAL	ASSOCIATE PROFESSOR
123.	ELECTRONICS AND COMM. ENGG.	Dr. GURJIT KAUR	ASSOCIATE PROFESSOR
124.	ELECTRONICS AND COMM. ENGG.	Dr. DEVA NAND	ASSISTANT PROFESSOR
125.	ELECTRONICS AND COMM. ENGG.	MR. AVINASH RATRE	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
126.	ELECTRONICS AND COMM. ENGG.	MR. AJAI K. GUATAM	ASSISTANT PROFESSOR
127.	ELECTRONICS AND COMM. ENGG.	DR. N.JAYANTHI	ASSISTANT PROFESSOR
128.	ELECTRONICS AND COMM. ENGG.	DR. SUDIPTA MAJUMDAR	ASSISTANT PROFESSOR
129.	ELECTRONICS AND COMM. ENGG.	DR. MALTI BANSAL	ASSISTANT PROFESSOR
130.	ELECTRONICS AND COMM. ENGG.	DR. PRIYANKA JAIN	ASSISTANT PROFESSOR
131.	ELECTRONICS AND COMM. ENGG.	MR. ANURAJ CHAUHAN	ASSISTANT PROFESSOR
132.	ELECTRONICS AND COMM. ENGG.	MR. PIYUSH TEWARI	ASSISTANT PROFESSOR
133.	ELECTRONICS AND COMM. ENGG.	DR. YASHNA SHARMA	ASSISTANT PROFESSOR
134.	ELECTRONICS AND COMM. ENGG.	MS. KRITI SUNEJA	ASSISTANT PROFESSOR
135.	ELECTRICAL ENGG.	DR. MADHUSHUDAN SINGH	PROFESSOR
136.	ELECTRICAL ENGG.	DR.NARENDRA KUMAR (I)	PROFESSOR
137.	ELECTRICAL ENGG.	DR. PRAGATI KUMAR	PROFESSOR
138.	ELECTRICAL ENGG.	DR. UMA NANAGIA	PROFESSOR
139.	ELECTRICAL ENGG.	DR. VISHAL VERMA	PROFESSOR
140.	ELECTRICAL ENGG.	DR. NARENDRA KUMAR(II)	PROFESSOR
141.	ELECTRICAL ENGG.	DR. SUMAN BHOWMICK	PROFESSOR
142.	ELECTRICAL ENGG.	DR. RACHNA GARG	PROFESSOR
143.	ELECTRICAL ENGG.	DR. BHARAT BHUSHAN	PROFESSOR
144.	ELECTRICAL ENGG.	DR. S.T.NAGARAJAN	PROFESSOR
145.	ELECTRICAL ENGG.	DR. J.N.RAI	PROFESSOR
146.	ELECTRICAL ENGG.	DR. ALKA SINGH	PROFESSOR
147.	ELECTRICAL ENGG.	DR. MADAN MOHAN TRIPATHI	PROFESSOR
148.	ELECTRICAL ENGG.	DR.MUKHTIAR SINGH	PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
149.	ELECTRICAL ENGG.	DR. DHEERAJ JOSHI	PROFESSOR
150.	ELECTRICAL ENGG.	DR.PRIYA MAHAJAN	PROFESSOR
151.	ELECTRICAL ENGG.	DR. N.K JAIN	PROFESSOR
152.	ELECTRICAL ENGG.	MR. NEERAJ KUMAR BHAGAT	ASSOCIATE PROFESSOR
153.	ELECTRICAL ENGG.	MR. RAM BHAGAT	ASSOCIATE PROFESSOR
154.	ELECTRICAL ENGG.	DR. SUDARSHAN KUMAR BABU VALLURU	ASSOCIATE PROFESSOR
155.	ELECTRICAL ENGG.	MR. DULI CHAND MEENA	ASSOCIATE PROFESSOR
156.	ELECTRICAL ENGG.	DR. MINI SREEJETH K.	ASSOCIATE PROFESSOR
157.	ELECTRICAL ENGG.	DR. MOHMMAD RIZWAN	ASSOCIATE PROFESSOR
158.	ELECTRICAL ENGG.	DR. VINOD KUMAR YADAV	ASSOCIATE PROFESSOR
159.	ELECTRICAL ENGG.	MR.RAMJEE LAL MEENA	ASSOCIATE PROFESSOR
160.	ELECTRICAL ENGG.	MR. PREM PRAKASH	ASSISTANT PROFESSOR
161.	ELECTRICAL ENGG.	MS. BHAVNESH JAINT	ASSISTANT PROFESSOR
162.	ELECTRICAL ENGG.	MR.ASHISH RAJESWAR KULKARNI	ASSISTANT PROFESSOR
163.	ELECTRICAL ENGG.	MR. ANIRUDDHA BARUN KUMAR BHATTACHARYYA	ASSISTANT PROFESSOR
164.	ELECTRICAL ENGG.	MR. KULDEEP SINGH	ASSISTANT PROFESSOR
165.	ELECTRICAL ENGG.	MS.GARIMA	ASSISTANT PROFESSOR
166.	ELECTRICAL ENGG.	MS. ANKITA ARORA	ASSISTANT PROFESSOR
167.	ELECTRICAL ENGG.	MR. HIMANSHU	ASSISTANT PROFESSOR
168.	ELECTRICAL ENGG.	DR. ANUP KR. MANDPURA	ASSISTANT PROFESSOR
169.	ELECTRICAL ENGG.	MR. SIKANDAR ALI KHAN	ASSISTANT PROFESSOR
170.	ELECTRICAL ENGG.	MR. SAURABH MISHRA	ASSISTANT PROFESSOR
171.	ENVIRONMENT ENGG.	DR.HARITASH ANIL KUMAR	ASSOCIATE PROFESSOR
172.	ENVIRONMENT ENGG.	MS. LOVLEEN GUPTA	ASSISTANT PROFESSOR
173.	ENVIRONMENT ENGG.	DR.RAJEEV KUMAR MISHRA	ASSISTANT ROFESSOR
174.	ENVIRONMENT ENGG.	MS. GEETA	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
175.	ENVIRONMENT ENGG.	SH. GOUR ANUNAY ASHOK KUMAR	ASSISTANT PROFESSOR
176.	HUMANITIES	DR. SEEMA SINGH	PROFESSOR
177.	HUMANITIES	MS. SAROJ BALA	ASSOCIATE PROFESSOR
178.	HUMANITIES	DR. NAND KUMAR	ASSOCIATE PROFESSOR
179.	HUMANITIES	Dr. RAJIV RANJAN DWIVEDI	ASSOCIATE PROFESSOR
180.	HUMANITIES	MS. PARINITA SINHA	ASSISTANT PROFESSOR
181.	INFORMATION TECHNOLOGY	DR. KAPIL SHARMA	PROFESSOR
182.	INFORMATION TECHNOLOGY	Dr. SEBA SUSAN RANJAN	ASSOCIATE PROFESSOR
183.	INFORMATION TECHNOLOGY	DR. DINESH KUMAR VISHWAKARMA	ASSOCIATE PROFESSOR
184.	INFORMATION TECHNOLOGY	MS. RITU AGARWAL	ASSISTANT PROFESSOR
185.	INFORMATION TECHNOLOGY	MS. ANAMIKA CHAUHAN	ASSISTANT PROFESSOR
186.	INFORMATION TECHNOLOGY	MS. PRIYANKA MEEL	ASSISTANT PROFESSOR
187.	INFORMATION TECHNOLOGY	MR. JASRAJ MEENA	ASSISTANT PROFESSOR
188.	MECHANICAL ENGG.	Dr.SAGAR MAJI (DIVERTED CAPACITY AT GBPEC)	PROFESSOR
189.	MECHANICAL ENGG.	DR. S.K.GARG	PROFESSOR
190.	MECHANICAL ENGG.	DR. NAVEEN KUMAR	PROFESSOR
191.	MECHANICAL ENGG.	DR.SAMSHER	PROFESSOR
192.	MECHANICAL ENGG.	DR. R.S.MISHRA	PROFESSOR
193.	MECHANICAL ENGG.	DR.VIKAS RASTOGI	PROFESSOR
194.	MECHANICAL ENGG.	DR.D.S.NAGESH	PROFESSOR
195.	MECHANICAL ENGG.	DR.REETA WATTAL	PROFESSOR
196.	MECHANICAL ENGG.	DR.VIPIN	PROFESSOR
197.	MECHANICAL ENGG.	DR.ATUL KUMAR AGRAWAL	PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
198.	MECHANICAL ENGG.	DR. RAJ KUMAR SINGH	PROFESSOR
199.	MECHANICAL ENGG.	Dr. RAMESH CHANDRA SINGH	PROFESSOR
200.	MECHANICAL ENGG.	Dr.AMIT PAL	PROFESSOR
201.	MECHANICAL ENGG.	DR. RAVINDERJIT SINGH WALIA (On Lien)	PROFESSOR
202.	MECHANICAL ENGG.	DR.RAJESH KUMAR	PROFESSOR
203.	MECHANICAL ENGG.	Dr. QASIM MURTAZA	PROFESSOR
204.	MECHANICAL ENGG.	Dr.RANGANATHAN M.S.	PROFESSOR
205.	MECHANICAL ENGG.	DR.BHARAT BHUSHAN ARORA	PROFESSOR
206.	MECHANICAL ENGG.	DR. ASHOK KUMAR MADAN	PROFESSOR
207.	MECHANICAL ENGG.	Dr.RAJIV CHAUDHARY	PROFESSOR
208.	MECH, ENGG.	Dr.VIJAY GAUTAM	PROFESSOR
209.	MECHANICAL ENGG.	MR. VISHAV KAMAL	ASSOCIATE PROFESSOR
210.	MECHANICAL ENGG.	MR.P.V.RAM KUMAR	ASSOCIATE PROFESSOR
211.	MECHANICAL ENGG.	MR.PRADEEP K.JAIN	ASSOCIATE PROFESSOR
212.	MECHANICAL ENGG.	Dr.AKHILESH ARORA	ASSOCIATE PROFESSOR
213.	MECHANICAL ENGG.	Dr.GIRISH KUMAR	ASSOCIATE PROFESSOR
214.	MECHANICAL ENGG.	DR. ANIL KUMAR	ASSOCIATE PROFESSOR
215.	MECHANICAL ENGG.	Dr.MAHENDRA SINGH NIRANJAN	ASSOCIATE PROFESSOR
216.	MECHANICAL ENGG.	Dr. PARAS KUMAR	ASSISTANT PROFESSOR
217.	MECHANICAL ENGG.	DR.MANJUNATH K (On Lien)	ASSISTANT PROFESSOR
218.	MECHANICAL ENGG.	Mr.SANJAY KUMAR	ASSISTANT PROFESSOR
219.	MECHANICAL ENGG.	Mr.KROVVIDI SRINIVAS	ASSISTANT PROFESSOR
220.	MECHANICAL ENGG.	Mr.NAUSHAD AHMAD ANSARI	ASSISTANT PROFESSOR
221.	MECHANICAL ENGG.	Mr.ROOP LAL	ASSISTANT PROFESSOR
222.	MECHANICAL ENGG.	Dr.MOHAMMAD ZUNAID	ASSISTANT PROFESSOR
223.	MECHANICAL ENGG.	DR.PRAVIN KUMAR	ASSISTANT PROFESSOR
224.	MECHANICAL ENGG.	Dr. SAURABH AGARWAL	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
225.	MECHANICAL ENGG.	Dr.N.YUVRAJ	ASSOCIATE PROFESSOR
226.	MECHANICAL ENGG.	DR. PUSHPENDRA SINGH	ASSISTANT PROFESSOR
227.	MECHANICAL ENGG.	Dr.RAGHVENDRA GAUTAM	ASSISTANT PROFESSOR
228.	MECHANICAL ENGG.	Ms. NAVRITI GUPTA	ASSISTANT PROFESSOR
229.	MECHANICAL ENGG.	Dr. SUSHILA RANI	ASSISTANT PROFESSOR
230.	DELHI SCHOOL OF MANAGEMENT	DR. PRADEEP KUMAR SURI	PROFESSOR
231.	DELHI SCHOOL OF MANAGEMENT	DR. G.P MAHESHWARI	PROFESSOR
232.	DELHI SCHOOL OF MANAGEMENT	DR. RAJAN YADAV	PROFESSOR
233.	DELHI SCHOOL OF MANAGEMENT	DR. SHIKHA N KHERA	ASSISTANT PROFESSOR
234.	DELHI SCHOOL OF MANAGEMENT	DR. VIKAS GUPTA	ASSISTANT PROFESSOR
235.	DELHI SCHOOL OF MANAGEMENT	DR. ARCHNA SINGH	ASSISTANT PROFESSOR
236.	DELHI SCHOOL OF MANAGEMENT	MS. MEHA KANDAPAL	ASSISTANT PROFESSOR
237.	DELHI SCHOOL OF MANAGEMENT	Dr. SONAL THUKRAL	ASSISTANT PROFESSOR
238.	DELHI SCHOOL OF MANAGEMENT	MS. DEEPALI MALHOTRA	ASSISTANT PROFESSOR
239.	DELHI SCHOOL OF MANAGEMENT	MS. DEEPSHREE	ASSISTANT PROFESSOR
240.	DELHI SCHOOL OF MANAGEMENT	SH. CHANDAN SHARMA	ASSISTANT PROFESSOR
241.	DELHI SCHOOL OF MANAGEMENT	SH. MOHIT BENIWAL	ASSISTANT PROFESSOR
242.	DELHI SCHOOL OF MANAGEMENT	SH. YASHDEEP SINGH	ASSISTANT PROFESSOR
243.	DELHI SCHOOL OF MANAGEMENT	SH. DHIRAJ KUMAR PAL	ASSISTANT PROFESSOR
244.	DESIGN	SH.PARTHA PRATIM DAS	ASSISTANT PROFESSOR

S. No.	DEPARTMENT	FACULTY NAME	DESIGNATION
245.	DESIGN	SH. NEERAJ RATHEE	ASSISTANT PROFESSOR
246.	DESIGN	MS. TARUNA SINGH	ASSISTANT PROFESSOR
247.	DESIGN	SH.VARUN SINGH	ASSISTANT PROFESSOR
248.	DESIGN	DR. RAVINDER SINGH	ASSISTANT PROFESSOR
249.	USME (EAST DELHI CAMPUS)	DR. AMIT MOOKARJEE	PROFESSOR
250.	USME (EAST DELHI CAMPUS)	SH. JAGVINDER SINGH	ASSISTANT PROFESSOR
251.	USME (EAST DELHI CAMPUS)	SH. ANURAG CHATURVEDI	ASSISTANT PROFESSOR
252.	USME (EAST DELHI CAMPUS)	MS. HARLEEN KAUR	ASSISTANT PROFESSOR
253.	USME (EAST DELHI CAMPUS)	MS. PRIYA MALHOTRA	ASSISTANT PROFESSOR
254.	USME (EAST DELHI CAMPUS)	MS.PALLAVI KALRA	ASSISTANT PROFESSOR
255.	USME (EAST DELHI CAMPUS)	MS. VARSHA SEHGAL	ASSISTANT PROFESSOR
256.	USME (EAST DELHI CAMPUS)	SH. HARSH PARDHAN	ASSISTANT PROFESSOR
257.	USME (EAST DELHI CAMPUS)	DR. NAVAL GARG	ASSISTANT PROFESSOR
258.	USME (EAST DELHI CAMPUS)	SH. PUNEET KUMAR ARORA	ASSISTANT PROFESSOR
259.	USME (EAST DELHI CAMPUS)	SH. RAJESH SHARMA	ASSISTANT PROFESSOR
260.	USME (EAST DELHI CAMPUS)	MS. RATNAM MISHRA	ASSISTANT PROFESSOR
261.	USME (EAST DELHI CAMPUS)	MS. AKANKSHA KAUSHIK	ASSISTANT PROFESSOR
262.	USME (EAST DELHI CAMPUS)	SH. VIRENDER KUMAR	ASSISTANT PROFESSOR

FORM FOR REPORTING CASES OF USE OF OR ATTEMPT TO USE UNFAIR MEANS AT THE UNIVERSITY EXAMIANTION

Note: One sheet should be used for one candidate only, if printed forms run short, the form should be photocopied and used.

PART - I

Name of examination .....

Name of Student .....

Roll No. .....

Complete Postal Address (Including Phone/Mobile No.) .....

.....

Subject in which the candidate is reported to have used or intended to use unfair means

.....

Day ..... Date ..... Time .....

1. Particular of book, papers, electronic gadgets etc found in possession of the student and submitted along with the answer sheet (all these materials should be signed by the Invigilator of examination and the student).

   Name of book (if any)

   (a) .....

   (b) .....

   (c) .....

   Number of leaves of books .....

   Number of (a) Manuscript slips: ..... Sheets .....

   Any other articles such as electronic gadget etc.

   (a) .....

   (b) .....

   (c) .....

PART - II

2. Statement of the student to be obtained at once in his/her own handwriting.

Were the above articles recovered from your possession? .....

.....

Why did you keep them with you inspite of clear instructions? .....

.....

Did you make any use of them? ....

.....

Have you anything else to state? .....

.....

Date ..... Time ..... (Signature of Student)

Certified that this statement was made in my presence.

Certified that the candidate declined to give any statement. (Certificate not applicable should be crossed by the invigilator)

Date ..... Time ..... (Signature of Invigilator)

Date ..... Time ..... (Signature of Superintendent)

ANNEXURE - E

GUIDELINES FOR ATTENDANCE RECORDS AND PREPARATION OF LIST OF STUDENTS NOT ELIGIBLE TO APPEAR IN THE END TERM EXAMIANTION

Step	Action	Performa to be filled	Target Dates
First	Communication form Chairman, BoS to course coordinator requesting to submit the list of students having short attendance on specified format up to prescribed date.	ATT.1/6	One week before the last date of display of attendance as per academic calendar
Second	Consolidation of the list of such students by Chairman, BOS and Notice from Chairman, BoS for short attendance.	ATT.2/6	
Third	Communication from Academic (PG) to parent/ guardian of student having short attendance.	ATT.3/6	

Step	Action	Performa to be filled	Target Dates
Fourth	Communication from Chairman, BoS to course Coordinator requesting to submit the final list of students having short attendance on specified format up to prescribed date.	ATT.4/6	
Fifth	Preparation of list of detained students by BoS and recommendation to this effect.	ATT.5/6	
Sixth	Notices from Chairman, BoS regarding detainee to Students Notice Board and Academic (PG).	ATT.6/6	

From Chairman, BoS to Course Coordinators

DEPARTMENT OF .....

.....

NOTICE

LIST OF STUDENTS HAVING SHORTAGE OF ATTENDANCE (<75%)

Academic Year ..... Class .....

Semester ..... Odd/Even

Course Title ..... Course Code .....

All Course Coordinators,

Please inform the name(s) of PG students having less that 75% attendance (L+T+P) upto ..... (as per academic calendar) in the course of which you are the coordinator in Odd /Even Semester ..... The information may please be sent to undersigned **latest by** ..... In the proforma given below along with a photocopy of attendance record of entire class. If there is no short attendance case in your course, please write NIL in the proforma.

S. No.	Student Enrolment / Roll Number	Name of Student	Branch	Attendance Record (L+T+P)		
				Classes Held	Classes Attended	Percentage of Attendance

Signature

Name of the Course Coordinator .....

From Chairman, BoS to Notice Boards

DEPARTMENT OF .....

.....

NOTICE

LIST OF STUDENTS HAVING SHORTAGE OF ATTENDANCE (<75%)

Academic Year ..... **Class** .....

Semester ..... **Odd /Even**

As per attendance Regulations in force, a student is required to have attended at least 75% of the total classes held in a subject, in order to be eligible to appear in the end-term examination of that subject. Upto ..... (as per academic calendar, the following students are having short-attendance in the courses indicated against their names. These students are advised to be extra careful and make up for the short attendance; otherwise they may be debarred from appearing in the end term examination.

S. No.	Student Enrolment/ Roll No.	Name of Student	Branch	Course		Percentage of Attendance
				Code	Title	

Chairman, BOS

Copy to:

1. Academic (PG) to inform student's parent / guardian.
2. Students Notice Board.
3. Respective program advisors with the request to call the students and counsel them.

ATT.3/6

NOTICE UNDER CERTIFICATE OF POSTING
From Academic (PG) to student's parent / guardian
LIST OF STUDENTS HAVING SHORTAGE OF ATTENDANCE (<75%)

No: **Dated** .....

Dear Guardian / Parent,

Your ward is studying M. Tech.. (.....Year) degree course at this University.

I have to inform you that as per M. Tech. Regulations of the University governing the attendance of the students, a student is required to have at least 75% attendance in a course in a semester to be eligible to appear in the End-Term Examination of that course. But your ward is not attending the classes regularly and his / her attendance has fallen below the required level in following course(s).

S.No.	Course		
	Code	Title	Percentage of attendance

This is for your kind information. You may also kindly advise your ward to be regular in attending the classes and bring his/her attendance to the required level failing which he / she will not be allowed to appear in the examinations.

Yours truly,

Academic (PG)

ATT.4/6

From Chairman, BoS to Notice Boards

LIST OF STUDENTS HAVING SHORTAGE OF ATTENDANCE (<75%)

DEPARTMENT OF .....

.....

Academic Year .....

....

Semester ..... Odd / Even

Course Title ..... Course Code .....

All Course Coordinators,

Please inform the names of PG students having less that 75% attendance (L+T+P) upto ..... (as per academic calendar) in the course of which you are the coordinator in Odd /Even Semester ..... The information may please be sent to undersigned **latest by** ..... In the proforma given below along with a photocopy of attendance record of entire class. If there is no short attendance case in your course, please write NIL in the proforma.

S. No.	Student Enrolment / Roll No.	Name of Student	Branch	Attendance Record (L+T+P)		
				Classes Held	Classes Attended	Percentage of Attendance

Name of the Course Coordinator ..... Signature

ATT.5/6

From Chairman, BOS to Student Notice Boards

DEPARTMENT OF .....

.....

LIST OF STUDENTS NOT ELIGIBLE TO APPEAR IN END-TERM EXAMINATION AS PER REGULATIONS

Academic Year ..... Class .....

Semester ..... Odd / Even

Course Title .....

Course Code .....

S.No.	Enrolment / Roll No.	Name of Student	Percentage of Attendance

1. (a) Dates on which the names of the students were placed on the Notice Boards of the Department .....

   (b) If the names of the students were note placed on the Notice Boards, specify the reasons for the same.

2. As per the information given by all teachers of this subject, there are no other cases of shortage of attendance in this subject.

3. The students as listed above are detained from appearing in the end term examination in the subject noted above as per the attendance record given above.

Signature of Chairman, BoS
Members of Academic Committee
(CHAIRMAN)

ATT.6/6

From Academic (PG)

LIST OF STUDENTS HAVING SHORTAGE OF ATTENDANCE (<75%)

Academic Year .....

.....

Class .....

Semester .... Odd / Even

OFFICE ORDER

As per Attendance Regulations ..... and recommendation made by competent authority, following students are not eligible to appear in End-Term Examination of Odd / Even semester in the courses mentioned before their name. Invigilators are requested not to allow these students to appear in the concerned examinations.

S.No.	Course		Roll number of students detained for end term examinations.
	Code	Title	

Date :.....

Academic (PG)

Copy to:

1. Dean Academic (PG)
2. All HODs
3. Superintendent of Examinations (M. Tech.)
4. Registrar
5. Controller of Examinations.

Academic Section (PG)
Delhi Technological University

FORM OF APPLICATION

for

Make-up Examination for Mid / End Semester (Odd / Even) Examination 201____ - 201____

The form when completed should be submitted to: **Academic Section(P.G.),** ***Delhi Technological University***	*(For use by the Academic Section {PG})* **Permitted** by Dean Acad.(PG) / **NOT Permitted** by Dean Acad.(PG)

To be filled in by the applicant

Name: .....

Roll No: .....

Mobile No. .....

Email: .....

Address for Communication:

.....

.....

.....

A. Courses requested for Make-up Examination:

S. No.	Course Code	Name of the Course	Credits	Date & time slot of the Exams scheduled	Reason for missing the Exams
1					
2					
3					
4					
5					
6					

B. Supported Mandatory Documents for the claim:
(*Please tick the annexed documents below*)

1	Recommendation of concerned Warden (***if the student resides in University Hostel***)
2	Medical Certificate issued by the Medical Officer of the Hospital the student was admitted duly endorsed by Medical Officer of University Health Centre
3	Proof of admission in Hospital and discharge slip etc
4	Proof of medical tests conducted
5	Fitness certificate of the hospital
6	Endorsement by parent/guardian on the certificate of treatment (***if the student is a Day Scholar***)
7	Medical certificate from hospital where Parents/real brother or sister/spouse was admitted in ICU duly endorsed by Medical Officer of University Health Centre
8	Prior Approval of Dean Academic (PG) for any authorized work in the academic interests

DECLARATION

I hereby solemnly declare that the foregoing facts are true and correct and nothing is false therein and nothing material has been concealed there from. I also agree that in case any information given by me herein before is found false at later date, the result for the requested courses for make-up examination be cancelled.

Signature of the Parents/Guardian

Name (in Capital Letters)

Date :

Place :

Signature of Student

Name (in Capital Letters)

Date :

Place :



DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Shahbad Daulatpur, Bawana Road, Delhi-110042

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