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	-	
	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	-	17
	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
Group F	Track 1													
	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