

DELHI TECHNOLOGICAL UNIVERSITY														
SCHEME OF TEACHING AND EVALUATION														
MASTER OF TECHNOLOGY IN THERMAL ENGINEERING ( THE )														
Semester-I														
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1	THE501	Numerical Methods for Engineering applications	Core	4	3	0	2	15	25	20	40	-	24
	2	THE503	Advanced Power Plant Engineering	Core	4	3	0	2	15	25	20	40	-	
	3	THE505	Thermal Systems	Core	4	3	0	2	15	25	20	40	-	
	4	THE507	Refrigeration & HVAC Engineering	Core	4	3	0	2	15	25	20	40	-	
	5	THE509x	Department Elective 1	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	6	THE511 (Online)	Self-Study	-	2	-	-	-	-	-	-	50	-	
	7	THE513 (Online)	Skill Enhancement Course 1	-	2	-	-	-	-	-	-	50	-	
	8		Audit Course		0	-	-	-	-	-	-	-	-	
Semester-II														
	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1	THE502	Turbomachines	Core	4	3	0	2	15	25	20	40	-	24
	2	THE504	Theoretical & Computational Fluid Dynamics	Core	4	3	0	2	15	25	20	40	-	
⌚	3	THE506x	Department Elective 2	Elective	4	3/4	0	2/0	15/20	25/0	20/30	40/50	-	

	4	THE508x	Department Elective 3	Elective	3	3/4	0	2/0	15/20	25/0	20/30	40/50	-	
	5	THE 510 (online)	Research Methodology & IPR	-	4	-	-	-	-	-	-	100	-	
	6	THE 512 (online)	Skill Enhancement Course 2/Industrial Training	-	4	-	-	-	-	-	-	100		

### Semester-III

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1	THE601	Optimal Design of Thermal Systems	Core	4	3	0	2	15	25	20	40	-	16
	2	THE603 (online)	Open Elective 1	-	4	-	-	-	-	-	-	100		
	3	THE605	Minor Project/Research Thesis/Patent	-	8	-	-	16	-	-	-	-	100	

### Semester-IV

	S.No.	Course Code	Course Name	Type/Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE	Total Credits
	1	THE602	Major Project/Research Thesis/Patent	Core	16	0	0	32	-	-	-	-	100	16

**List of Electives**

<b>THE 509 Department Elective 1</b>	<b>THE 506 Department Elective 2</b>	<b>THE 508 Department Elective 3</b>	<b>THE 603Open Elective 1</b>
THE 5091Advanced I C Engines	THE 5061 Experimental methods in Thermal Engineering	THE 5081Clean Energy Resources	THE 6031 Ocean thermal Energy Conversion Systems
THE 5092 Combustion & Emissions	THE 5062Optimization Techniques	THE 5082 Measurement & Control Techniques	THE 6032Two Phase Flow Heat Transfer
THE 5093 Advanced Fluid Dynamics	THE 5063 Finite Element Methods	THE 5083 Advanced Cryogenic systems	THE 6033Advanced Energy Systems
THE 5094 Solar Thermal Engineering	THE 5064 Steam and Gas Turbines	THE 5084 Micro-fluidics	THE 6034Alternative Fuels
THE 5095 Energy Audit and Management	THE 5065 Exergy Analysis of Thermal Systems	THE 5085 Combustion Modelling	THE 6035Dynamics and Control of Mechanical Systems
THE 5096 Design of Heat Exchanger	THE 5066 Thermal Energy Storage systems	THE 5086 Hydrogen & Fuel cell	THE 6036 Convective Heat Transfer

## 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 FStoeckerandJ W Jones, McGraw Hill
2. Principles of Refrigeration by Dossat R.J. Wiley & Sons

### **THE5403Advanced 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 propertiesof 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 RP Sharma and ML 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 SamsnerGautam, 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 incompressible 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,

### **THE5303Optimization 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, variationalformulation,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 of Renewable & 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 KChaudhary, Tata McGraw-Hill

## SEMESTER II

### **THE502Energy 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

### **THE504Turbo 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-impulseturbinestage(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. 1.Turbines, compressors and Fans by S. M. Yahya, Tata McGraw Hill
2. Steam & Gas Turbines by J. F. Lee, McGraw Hill

### **THE5402Advanced 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.

### **THE5404Advance 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 byHyoung Woo Oh, InTech.
2. Physical Fluid Dynamics by D.J. Tritton, Springer

### **THE5406Advance 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:

Refrigeration and Air Conditioning by C P Arora, Tata McGraw-Hill

### **THE5304Solar 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.

### **THE5306Thermal Energy Conservation**

Waste Heat Recovery, Power Plant Cycles - Energy Cascading, Rankine Cycle and its 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

### **THE5202Steam 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 processes, 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 RP Sharma and ML 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, Kamel 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, Environment 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:

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:

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, Soyabean 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:

Alternative Fuels for Transportation by Arumugam S. Ramadhas, CRC Press