SYLLABI

for

M. Tech. Programme

in

Mechanical Engineering

(Thermal & Fluids Engineering)

DEPARTMENT OF

MECHANICAL ENGINEERING

National Institute Of Technology Manipur

Imphal – 795004

India

DEPARTMENT OF MECHANICAL ENGINEERING

M. Tech. SYLLABUS

SEMESTER I

Code	Subject	Lecture	Tutorial	Practical	Credit
MA521	Advanced Engineering Mathematics	3	0	0	6
ME507	Advanced Thermodynamics	3	0	0	6
ME509	Viscous Fluid Flows	3	0	0	6
ME511	Thermal-Fluids Experimentation	3	0	0	6
ME5XX	Elective -I	3	0	0	6
ME531	Thermal-Fluids Experimentation Laboratory	0	0	3	3
	Total	15	0	3	33

SEMESTER II

Code	Subject	Lecture	Tutorial	Practical	Credit
ME506	Convective Heat Transfer	3	0	0	6
ME508	Advanced I C Engines	3	0	0	6
ME5XX	Elective -II	3	0	0	6
ME5XX	Elective -III	3	0	0	6
ME532	Computational Laboratory	0	0	3	3
ME534	Seminar	0	0	2	2
	Total	12	0	5	29

SEMESTER III

Code	Subject	Lecture	Tutorial	Practical	Credit
ME631	Dissertation Preliminaries	0	0	24	24
	Total	0	0	24	24

SEMESTER VI

Code	Subject	Lecture	Tutorial	Practical	Credit
ME632	Dissertation	0	0	24	24
	Total	0	0	24	24

Total Number of Credit: 110

LIST OF DEPARTMENTAL ELECTIVES - I

Code	Subject	Lecture	Tutorial	Practical	Credit
ME551	Finite Element Method	3	0	0	6
ME553	Energy Conservation and Waste Heat Recovery	3	0	0	6
ME555	Refrigeration and Air-conditioning Technologies	3	0	0	6
ME557	Solar Thermal Engineering	3	0	0	6
ME559	Heat Transfer in Material Processing	3	0	0	6
ME561	Alternate Fuels	3	0	0	6

LIST OF DEPARTMENTAL ELECTIVES - II&III

Code	Subject	Lecture	Tutorial	Practical	Credit
ME552	Power Plant Engineering	3	0	0	6
ME554	Combustion Engineering	3	0	0	6
ME556	Optimization Methods in Engineering	3	0	0	6
ME558	Renewable Energy	3	0	0	6
ME560	Cryogenics	3	0	0	6
ME562	Computational Fluid Dynamics	3	0	0	6
ME564	Environmental Pollution and Control	3	0	0	6
ME566	Advanced Turbomachines	3	0	0	6
ME568	Steam and Gas Turbines	3	0	0	6
ME570	Design of Heat Exchange Equipment	3	0	0	6
ME572	Advanced Thermal Storage Technologies	3	0	0	6
ME574	Heat Transfer Applications	3	0	0	6
ME576	Two Phase Flow Heat Transfer	3	0	0	6
ME578	Fire Dynamics and Engineering	3	0	0	6

SEMESTER I

MA521 **ADVANCED ENGINEERING MATHEMATICS** **(3-0-0-6)**

In relation to mechanical engineering applications, such as, heat transfer, fluid mechanics, vibrations, dynamics and others, the following topics will be covered:

Partial differential equations - characteristics and classification of 2nd order PDEs. separation of variables, special functions, Eigen function expansions, Fourier integrals and transforms, Laplace transforms, methods of characteristics, self-similarity.

Linear algebra: matrix theory, solution of linear system of algebraic and differential equations; round-off errors, pivoting and ill-conditioned matrices. Eigen values and eigenvectors. Unitary, hermitian and normal matrices.

Numerical Methods: Lagrange interpolation, splines. integration–trapezoid, Romberg, Gauss, adaptive quadrature. Explicit and implicit methods, multi-step methods, Runge-Kutta and predictor-corrector methods, boundary value problems, eigen value problems, systems of differential equations, stiffness. Accuracy, stability and convergence. Alternating direction implicit methods. Non-linear equations.

Texts:

1. E. Kreyzig, Advanced Engineering Mathematics, New Age International, 2006.
2. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 3rd Ed., New Age International, 2008.
3. M.K. Jain, S.R.K. Iyenger and R.K. Jain, Computational Methods for Partial Differential Equations, New Age International, 2008.
4. P.V. O'Neil, Advanced Engineering Mathematics, Cengage Learning, 2013.

References:

1. D. S. Watkins, Fundamentals of Matrix Computations, John Wiley, 2004.
2. D.S. Chandrashekaraiah and L. Debnath, Continuum Mechanics, Academic Press, 2014.
3. R. Courant and D. Hilbert, Methods of Mathematical Physics, Wiley, 2008.
4. G. B. Arfken, H. J. Weber and F.Harris, Mathematical Methods for Physicists, 7th Ed., Academic Press, 2013.

ME509 **VISCOUS FLUID FLOWS** **(3-0-0-6)**

Introduction: stress-deformation relation, vector and tensor, vorticity and circulation, erivation of Navier-Stokes equations; Exact solutions: Couette flow, Hagen-Poiseuille flow, tokes problems; Complex variable and Potential flow, Two-dimensional boundary layer: lassius solution, Kármán-Pohlhausen method, effect of pressure gradient, separation and control, Waltz's-Quadrature formula; Flow instability: concept of small-perturbations, linearized stability of parallel viscous flows, Orr-Sommerfeld equation; Turbulent boundary layers: Reynolds stress tensor, energy cascade, mixing length hypothesis, universal law of wall, fully developed turbulent flow through a pipe and channel, power law and effect of wall roughness; Compressible flow: condition of compressibility, subsonic, supersonic and hypersonic flows, shock and Mach waves, shock-boundary layer interactions; Special topics: Transition and turbulence, fluid-solid interaction, free-surface flow, bio-fluids, non-Newtonian flows, CFD and Measurements (optional and limited to any one).

Texts:

1. B.R.Munson, D.F.Young and T.H.Okiishi., Fundamental of Fluid Mechanics, John Wiley and Sons., 2011.
2. F.M.White, Viscous Fluid Flow, McGraw-Hill international editions., 2001.
3. Turbulence, An Introduction for Scientists and Engineers – P. A. Davidson – Oxford, 2015.

References:

1. P.M.Gerhar, R.J.Gross and J.I.Hochstein., Fundamentals of Fluid Mechanics, Addison-Wesley Publishing Co., 1993.
2. H.Schlichting, Boundary Layer Theory, McGraw-Hill Series in Mechanical Engineering, 1979.
3. F.M.White, Fluid Mechanics, McGraw-Hill international editions., 2011.
4. An Introduction to Fluid Dynamics – G. K. Batchelor – Cambridge University Press, 2000.

ME511 THERMAL-FLUIDS EXPERIMENTATION (3-0-0-6)

Statistics: Distributions, estimators, confidence levels, sample size, test of hypothesis, Goodness-of-fit test Chauvenet's criteria; Regression analysis, co-relations. Uncertainty analysis. Design of experiments. Instruments: Specifications. Static and dynamic characteristics. Instruments for measuring distance, profile, pressure, temperature, velocity, flow rate, level, speed, force, torque, noise, chemical analyses. Estimation of systematic errors. Steady state and transient response, Laboratory: Calibration. Experiments related to heat transfer, fluid mechanics, thermodynamics and gas dynamics. Also covers: LabView& Simulink, Analog Transducers, Hot-wire/Hot-Film & Cold-Wire/Cold-Film Anemomentry, Acoustic and Laser Doppler velocimetry, Full-field (2-D) quantitative imaging techniques like PIV& PLIF; Particle based techniques – PTV & PDPA, Optical Density Based Techniques – Schlieren, Shadograph.

Texts:

1. Holman, Experimental Methods for Engineers, 6e, McGraw-Hill, 2012.
2. Doeblin, Engineering Experimentation, McGraw-Hill, 2010.
3. Stavros Tavoularis, Measurement in Fluid Mechanics, Cambridge Univ. Press, 2005.

References:

1. U. Müller, K. G. Roesner, B. Schmidt, Recent Developments in Theoretical and Experimental Fluid Mechanics: Compressible and Incompressible Flows, Springer London, 2011.

ME507 ADVANCED THERMODYNAMICS (3-0-0-6)

Review of basic thermodynamics: Laws of thermodynamics, entropy, entropy balance for closed and open systems. Exergy: Concept of reversible work & irreversibility; Second law efficiency; Exergy change of a system: closed & open systems, exergy transfer by heat, work and mass, exergy destruction, exergy balance in closed & open systems; Exergy analysis of industrial systems – power systems and refrigeration systems. Cycle analysis and optimization: Regenerative reheat Rankine cycle and Brayton cycle, combined cycle power plants, multi-stage refrigeration systems. Thermodynamic optimization of irreversible systems: Finite time thermodynamics principles, optimization studies of various thermal systems, Minimization of entropy generation principle. Properties of Gas Mixtures: Equation of state and properties of ideal gas mixtures; Change in entropy on mixing; Partial molal properties for non-ideal gas mixtures. Thermodynamics of Reactive System: Conditions of equilibrium of a multiphase - multicomponent system; Second law applied to a reactive system; Condition for reaction equilibrium. Statistical-mechanical evaluation of thermodynamic properties of gases, liquids, and solids, Elementary kinetic theory of gases and evaluation of transport properties. Non-Equilibrium Thermodynamics of small scale systems.

Texts:

1. A. Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
2. M.J.Moran and H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 2012.
3. I. K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press, 20011.

References:

1. F.W.Sears and G. L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa Publishing House, New Delhi, 3rd edition, 1998.
2. M. W. Zemansky and R. H. Dittman, Heat and Thermodynamics, McGraw Hill International Editions, 7th edition, 2007.
3. F.W.Sears and G.L.Salinger, Thermodynamics, Kinetic Theory And Statistical Thermodynamics, Addision Wesley Publishing Company, 1975.
4. Wylen and Sontag, Fundamentals of Classical Thermodynamics, Wiley Eastern Limited, 1994.

ME531 THERMAL-FLUIDS EXPERIMENTATION LABORATORY (0-0-3-3)

Calibration of Pitot-static tube for gas (air) flow, orifice meter and ventury meter for liquid (water) flow through pipe Laminar and turbulent flow through pipes, pressure drop, heat transfer coefficient Flow over a cylinder – study of wake, drag coefficient and heat transfer coefficient Flow through converging and diverging nozzles Heat transfer by radiation and natural convection Drying of material by hot air Shell and tube heat exchangers – LMTD, pressure drop, heat transfer coefficient Plate heat exchangers – LMTD, pressure drop, heat transfer coefficient Pump and turbine efficiencies CoP of refrigeration cycles – VCR and VAR Efficiency and BHP of SI and CI engines Efficiency of Rankine cycle and Stirling cycle.

SEMESTER II

ME506 CONVECTIVE HEAT TRANSFER (3-0-0-6)

Conservation equations for mass, momentum, energy and species. Boundary layer flows, External laminar flow heat transfer. Internal laminar flow heat transfer, entrance region. Turbulent flow heat transfer, turbulent Prandtl number, external and internal flows. Natural convection in external and bounded flows. Mixed convection. Boiling–pool boiling and forced convection boiling in tubes. Condensation over a plate, tube and tube banks. Mass transfer. Applications to engineering problems.

Texts:

1. Adrian Bejan, Convective Heat Transfer, John Wiley and Sons, 2013.
2. W. M. Kays and E. M. Crawford, Convective Heat and Mass Transfer, Mc Graw Hill, 1993.

References:

1. Louis C Burmeister, Convective Heat Transfer, John Wiley and Sons, 1993.
2. Spalding D B, *"Introduction to Convective Mass Transfer",* McGraw Hill, 1963.
3. Bird R. B., Stewart W. E. and Lightfoot E. N., *" Transport Phenomena ",* John Wiley and sons, Inc., 1960.
4. Schlichting H., *"Boundary Layer Theory ",* Sixth edition, McGraw Hill , 1968.

ME508 ADVANCED I C ENGINES (3-0-0-6)

SPARK IGNITION ENGINES-Spark ignition Engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – factors affecting knock – Combustion chambers.

COMPRESSION IGNITION ENGINES-States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – spray structure, spray penetration and evaporation – air motion – Introduction to Turbo charging.

POLLUTANT FORMATION AND CONTROL-Pollutant – Sources – Formation of carbon monoxide, Unburnt hydrocarbon, NO_x, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles.

RECENT TRENDS-Lean Burn Engines – Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – laser Doppler, Anemometry.

Texts:

1. Internal combustion engines, Ganesan, Tata McGraw-Hill Education,(2008).
2. Engineering fundamentals of the internal combustion engine, Willard W. Pulkrabek, Pearson Prentice Hall, (2004).

References:

1. Introduction to Modeling and Control of Internal Combustion Engine Systems, Lino Guzzella, Christopher Onde, Springer, 2010

ME532 COMPUTATIONAL LABORATORY (0-0-3-3)

Writing programs using any computer languages for Solution of transcendental equations, solution of ordinary differential equations, Explicit and implicit methods of solving the fluid flow problems under various types of boundary conditions.Grid Generation Techniques, 1-D and 2-D stress analysis, 1-D and 2-D heat conduction with convective boundaries, Inviscid incompressible fluid flows, Use of any CFD commercial package.

ME534 SEMINAR (0-0-2-2)

Program Outcome (PO)-These subjects are introduced in the first year of M. Tech to: give students exposure to variety of topics through the medium of presenting seminars.

These will include seminars by faculty and research students in the department and by invited experts in the same or related departments.

DEPARTMENTALELECTIVE I

ME551 **FINITE ELEMENT METHOD** **(3-0-0-6)**

Introduction - Illustration using spring systems and simple problems - Weighted residualmethods Galerkin's method - Variational approach - Rayleigh-Ritz method.One-dimensional finite element analysis; bar element, beam element, frame element – Heattransfer problems. Two-dimensional finite element analysis; types of elements, shape functions, naturalcoordinate systems.Applications to structural mechanics - Numerical integration - Solution of finite elementequations. Fluid flow problems - Dynamic problems.

Texts:
1. J. N. Reddy, An Introduction to the Finite Element Method , McGraw Hill, 2000.
2. O C Zienkiewicz, The Finite Element Method: Its Basis & Fundamental, Elsevier editions, 2005.
3. T. R. Chandrupatla, Introduction to Finite Elements in Engineering, PHI, 2004.

References:
1. J. N. Reddy, An Introduction to Nonlinear Finite Element Method, Oxford Press, 2006.
2. R D Cook, Concepts and Applications of Finite Element Analysis, Willey, 2007.
3. Rao, The Finite Element Method in Engineering , Elsevier, 2011.
4. U. S. Dixit, Finite Element Methods for Engineers, Cengage, 2009.

ME553 **ENERGY CONSERVATION AND WASTE HEAT RECOVER** **(3-0-0-6)**

Energyresources and use. Potential for energy conservation. Optimal utilization offossil fuels. Total energy approach. Coupled cycles and combined plants.Cogeneration systems. Exergy analysis. Utilization of industrial waste heat.Properties of exhaust gas. Gas-to-gas, gas-to-liquid heat recovery systems.Recuperators and regenerators. Shell and tube heat exchangers. Spiral tube andplate heat exchangers. Waste heat boilers: various types and design aspects. Heat pipes: theory and applications in waste heat recovery. Prime movers: sources and uses of waste heat. Fluidized bed heatrecovery systems. Utilization of waste heat in refrigeration, heating,ventilation and air conditioning systems. Thermoelectric system to recoverwaste heat. Heat pump for energy recovery. Heat recovery from incinerationplants. Utilization of low grade reject heat from power plants. Need for energystorage: Thermal, electrical, magnetic and chemical storage systems.Thermo-economic optimization.

Texts:
1. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill, 2007.
2. Diwan P. And Dwivedi P., Energy Consevation, PEP Press, 2009.

References:
1. Pervez T., Randhawa S. E. and Sadiq N., Waste Heat Recovery and Energy Conservation of Arl Distillation Unit, LAP Lambert Acad. Publ., 2011.
2. Turner W. C. and Doty S., Energy Management Handbook, CRC Press, 2006
3. F. Kreith and R. E. West, Energy Efficiency, CRC handbook, CRC Press,1999

ME555 REFRIGERATION AND AIR-CONDITIONING TECHNOLOGIES (3-0-0-6)

INTRODUCTION- Introduction to Refrigeration - Unit of Refrigeration and C.O.P.– Ideal cycles- Refrigerants Desirable properties – Classification - Nomenclature - ODP & GWP.

VAPOUR COMPRESSION REFRIGERATION SYSTEM -Vapour compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – sub cooling and super heating- effects of condenser and evaporator pressure on COP- multi-pressure system - low temperature refrigeration - Cascade systems – problems. Equipment's: Type of Compressors, Condensers, Expansion devices, Evaporators.

OTHER REFRIGERATION SYSTEMS -Working principles of Vapour absorption systems and adsorption cooling systems – Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration - Magnetic - Vortex and Pulse tube refrigeration systems.

PSYCHROMETRIC PROPERTIES AND PROCESSES -Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air-conditioning processes, mixing of air streams.

AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION - Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load; Classifications, Layout of plants; Air distribution system; Filters; Air Conditioning Systems with Controls: Temperature, Pressure and Humidity sensors, Actuators & Safety controls.

Texts:

1. C. P. Arora *, Refrigeration and Air Conditioning*, Tata McGraw-Hill Education, 2000.
2. William C. Whitman, William M. Johnson, John A. Tomczyk, *Refrigeration & Air Conditioning Technology*, Thomson publication, 2005.
3. Ibrahim Dincer, Mehmet Kanoglu*, Refrigeration Systems and Applications*, Wiley publication, 2010.

References:

1. W F Stoecker and J W Jones, Refrigeration and Air Conditioning, McGrawHill International Editions, 1982.
2. J L Threkeld, Thermal Environmental Engineering, 2nd ed, Prentice Hall Inc, 1970.

ME557 SOLAR THERMAL ENGINEERING (3-0-0-6)

Solar radiation and modelling, solar collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentrators, Selective coatings, Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration, active and passive heating and cooling of buildings, Solar thermal power generation, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options, Industrial process heat systems, Solar thermal power generation and sterling engine, Solar economics.

Texts:

1. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 2000.
2. SoterisKalogirou, Solar Energy Engineering, Academic Press, 2013.

3. D. Yogi Goswami, Principles of Solar Engineering, CRC Press, 2013

References:

1. John A. Duffie, William A. Beckman, Solar Engineering of Thermal Process, Wiley, 2013.
2. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.

ME559 HEAT TRANSFER IN MATERIAL PROCESSING (3-0-0-6)

Review of Fundamentals. Finite Difference and Finite Element Methods. Modelling of thermal transport in manufacturing of metal based components, plastics, chemicals; drying, waste processing, glass fibre making, crystal growing, food processing. Design of a material processing equipment.

Texts:

1. M. V. C. Sastri, B. Viswanathan and S. S. Murthy, Metal Hydrides, Narosa Publishing House, 1998.
2. Yang Wen-Jei, Mochizuki S. and Nishiwaki N., Transport Phenomena in Manufacturing and Materials processing, Elsevier, 1994.
3. Lior N., Heat and Mass Transfer in Material Processing, Taylor & Francis, 1991.

References:

1. Bejan A. And Kraus A. D., Heat Transfer Handbook,Wiley& Sons, Inc. 2003.
2. Zumbrunnen D. A., Heat and Mass Transfer in Materials Processing and Manufacturing,ASME, New Orleans, 1993.

ME561 ALTERNATE FUELS (3-0-0-6)

Fossil fuels and their limitations, Engine requirements, potential alternative liquid and gaseous fuels, methods of production, properties, safety aspects, handling and distribution, use in engines, performance and emission characteristics, conversion of vegetable oils to their esters and effect on engine performance, use of gaseous fuels in engines, dual fuel combustion, surface ignition, additives, hybrid power plants and fuel cells.

Text :

1. M. Dayal, "Energy today & tomorrow ", I & B Horishr India, 1982.
2. Nagpal, "Power Plant Engineering ", Khanna Publishers, 1991.
3. James D. Halderman, James Linder, Automotive Fuel and Emission Control system, Prentice Hall, 2014.

References:

1. Norbeck, Joseph M., Hydrogen fuel for surface transportation, Publisher: Society of Automotive Engineers, 1996
2. The properties and performance of modern alternate fuels - SAE Paper No.841210. SAE Handbook.
3. Richard L., Alternate Fuels Guide Book Authors:: Publisher Society of Automotive Engineers, 1997.

DEPARTMENTALELECTIVE II&III

ME552 POWER PLANT ENGINEERING (3-0-0-6)

Review of various ideal cycles–Rankine and Brayton–and fuel-air cycles. Thermodynamics optimization of design parameters. Real cycle effects– internal and external irreversibilitites, pressure drops, heat loss, condenser air leakage, fouling of heat transfer surfaces, combustion losses–and their impact on the thermodynamic cycle. Optimization of 231 Mechanical Engineering real and double reheat cycles. Analysis of off-design performance. Combined cycles–ideal and real cycles– thermodynamic analysis. Design of alternate schemes for combined cycles–single, dual and triple pressure cycles, and their optimization. Retrofit of ageing power plants. Parametric analysis–effects of gas and steam cycle variables. Binary vapour and Kalina cycles. Thermochemical and H_2 -O_2 cycles. Cycles for nuclear power plants (PWR, BWR, PHWR, FBR). All simulations will involve extensive use of numerical techniques as part of laboratory work.

Text :

1. Wakil, El., Power Plant Technology, McGraw Hill, 1985.
2. Arora, S. C. and Domkundwar, S., Power Plant Engineering, Dhanpat Rai & Sons, 2012.
3. Sharma, P.C., Power Plant Engineering, S. K. Kataria & Sons, 2010.

References:

1. Glasstone, S. and Sesonske, A., Nuclear Reactor Engineering: Reactor Design Basics, Vol. I & II, CBS Publishers & Distributors Pvt. Ltd, 2004.

ME554 COMBUSTION ENGINEERING (3-0-0-6)

Introduction. Chemical thermodynamics and chemical kinetics. Conservation equations for multi-component systems. Premixed systems - detonation and deflagration, laminar flames, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching turbulent pre-mixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Practical aspects of coal combustion.

Text:

1. S. R. Turns, An Introduction to Combustion, 2nd Ed, McGraw Hill, 2000.
2. K. K. Kuo, Principles of Combustion, 2nd Ed, Wiley-Interscience, 2005.

References:

1. J. Warnatz, U. Mass and R. W. Dibble, Combustion, 3rd Ed, Springer, 2001.
2. F. A Wiiliams, Combustion Theory, 2nd Ed, Addison Wesley Publishing Company, 1985.

ME556 OPTIMIZATION METHODS IN ENGINEERING (3-0-0-6)

Introductionto optimization; Formulation of optimization problems; Classical optimizationtechniques; Linear Programming; Non-linear Programming; single variable,multi-variable and constrained optimization; Specialised algorithms for integerprogramming and geometric programming; Non-traditional optimization algorithms

Text:

1. S. S. Rao, Optimization: Theory and Applications, 2nd ed. Wiley Eastern, 1984.
2. K. Deb, Optimization for Engineering Design-Algorithms and Examples, Prentice Hall India, 1995.
3. J. S. Arora, Introduction to Optimum Design, MC Graw-Hill, 1989.

References:

1. G. V. Reklaitis, A. Ravindran and K. M. Ragsdell, Engineering OptimizationMethods and Applications, Wiley, 1983.
2. R. L. Fox, Optimization Methods for Engineering Design, Addison Wesley, 1971.

ME558 **RENEWABLE ENERGY** **(3-0-0-6)**

COMMERCIAL ENERGY - Coal, Oil, Natural Gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

SOLAR ENERGY - Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

WIND ENERGY -Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept.

BIO-ENERGY -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.

OTHER TYPES OF ENERGY -Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plants – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

Texts:

1. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986.
2. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012.

3. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill, 2007.

References:

1. Veziroglu, T.N., Alternative Energy Sources, Vol 5 and 6, McGraw-Hill, 1990.
2. Bent Sorensen, Renewable Energy, Elsevier, Academic Press, 2011.

ME560 CRYOGENICS (3-0-0-6)

Properties of solids for cryogenic systems, refrigeration and liquefaction - simple Linde cycle, Pre-cooledJoule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerantcascade cycle, ultra-low-temperature refrigerators, equipment associated with low-temperature systems,storage and transfer systems.

Text :

1. K. D.Timmerhaus and T.M. Flynn, Cryogenic Process Engineering, Plenum Press, 1989.
2. R. F. Barron, Cryogenic Systems, McGraw Hill, 1985.
3. R.B.Scott, Cryogenic Engineering, Van Nostrand and Co., 1962.

References:

1. H. Weinstock, Cryogenic Technology, 1969.
2. R.W. Vance, Cryogenic Technology, John Wiley & Sons, Inc., New York, London

ME562 COMPUTATIONAL FLUID DYNAMICS (3-0-0-6)

Review of governing equations for heat transfer and fluid flow and their categorization. Review of the solution procedure of system of linear equations. Finite Difference Method for heat transfer problems, Steady state heat conduction with heat source, Handling various boundary conditions, Convective-diffusive system – Upwind scheme, Transient heat conduction – explicit, implicit and Crank – Nicolson methods.Finite Volume Method:Formulation, calculation of fluxes at faces of control volume, Source term linearization, Discretization for convective terms – upwind, power law, QUICK schemes, Staggered grid and solution of incompressible fluid flow, SIMPLE algorithm and extensions to SIMPLER, SIMPLEC and PISO.

Texts:

1. Richard Pletcher, John Tannehill and Dale Anderson, `Computational Fluid Mechanics and Heat Transfer , CRC Press, 2012.
2. H.K. Versteeg and W. Malalasekera, `An introduction to computational fluid dynamics: The finite volume method 3e', Pearson Education, 2007.
3. J. D. Anderson Jr., `Computational Fluid Dynamics', McGraw-Hill International Edition, 1995.
4. Charles Hirsch, `Numerical Computation of Internal and External Flows', Vol.1 (1988) and Vol.2 (1990), John Wiley & Sons.
5. S.V. Patankar, `Numerical Heat Transfer and Fluid Flow', Hemisphere, 2000.

References:

1. J. H. Fergiger, M. Peric, `Computational Methods for Fluid Dynamics , Springer, 2002.
2. T. J. Chung `Computational Fluid Dynamics, Cambridge University Press, 2010.
3. C. A. J. Fletcher, `Computational Techniques for Fluid Dynamics Vol. 1 and 2, Springer, 1991.

ME564 **ENVIRONMENTAL POLLUTION AND CONTROL** **(3-0-0-6)**

INTRODUCTION-Global atmospheric change – greenhouse effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

AIR POLLUTION - Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipment's - issues in air pollution control – air sampling and measurement.

WATER POLLUTION -Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

WASTE MANAGEMENT -Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization.

OTHER TYPES OF POLLUTION FROM INDUSTRIES- Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies

Texts:

1. G.Masters, Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi, 2013
2. H.S.Peavy, D.R..Rowe, G.Tchobanoglous, Environmental Engineering McGraw- Hill BookCompany, NewYork, 1985.

References:

1. H.Ludwig, W.Evans,Manual of Environmental Technology in Developing Countries, . International Book Company, Absecon Highlands, N.J, 1991.
2.Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A Design Approach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.

ME566 **ADVANCED TURBOMACHINES** **(3-0-0-6)**

To understand the various systems, principles, operations and applications of different types of turbo machinery components. Energy transfer between fluid and rotor-classification of fluid machinery,-dimensionless parameters-specific speed-applications-stage velocity triangles-work and efficiency.

CENTRIFUGAL FANS AND BLOWERS: Types- stage and design parameters-flow analysis in impeller blades-volute and diffusers, losses, characteristic curves and selection, fan drives and fan noise.

CENTRIFUGAL COMPRESSOR: Construction details, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.

AXIAL FLOW COMPRESSOR: Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done simple stage design problems and performance characteristics.

AXIAL AND RADIAL FLOW TURBINES: Stage velocity diagrams, reaction stages, losses and coefficients, blade design principles, testing and performance characteristics.

Texts:

1. S.M. Yahya, Fundamentals of Compressible Flow, New Age International (P)Limited, New Delhi, 2003.
2. Stepanoff A.J., Turboblowers, John Wiley & Sons, 1970.

References:

1. Brunoeck, Fans, Pergamon Press, 1973.
2. Austin H. Church, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
3. Dixon, Fluid Mechanics, Thermodynamics of turbomachinery Pergamon Press, 1998.

ME568 **STEAM AND GAS TURBINES** **(3-0-0-6)**

Introduction, thermodynamics and fluid dynamics of compressible flow through turbines. Recapitulation of heat cycles of steam power plants and gas turbine engines. Application of CFD in turbines. Energy conversion in a turbine stage. Geometrical and gas dynamic characteristics of turbine cascades. Turbine cascades and losses in turbine stage efficiency. Multi-stage turbines, radial turbines, partial admission turbines, turbines for nuclear power plants. Steam turbines for co-generation, supercritical and marine applications. Steam and gas turbine components. Governing of steam and gas turbines. Strength and vibration aspects. Steam and gas turbines of major manufacturers. Future trends.

Texts:

1. V Ganesan, Gas Turbines, Tata McGraw-Hill Education, 2003.
2. Ahmed F. El-Sayed, Aircraft Propulsion and Gas Turbine Engines*,* CRC Press, 2008.
3. B. Lakshminarayana, Fluid Dynamics & Heat Transfer of Turbomachinery, John Wiley & Sons, 1996.
4. H. Cohen, Gas Turbine Theory, 4th Edition, Longman, 2000.

References:

1. Gas Turbines & Jet Propulsion, M.J. Sable M.S. Ramgir, Technical Publications, 2006.
2. S.L.Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, Pergamon Press, 1998.

ME570 DESIGN OF HEAT EXCHANGE EQUIPMENT (3-0-0-6)

Applications. Basic design methodologies – LMTD and effective-nessNTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor. Classification and types of heat exchangers and construction details. Design and rating of double pipe heat exchangers, compact heat exchangers, plate and heat pipe type, condensers, cooling towers. Heat exchanger standards and testing, Heat transfer enhancement and efficient surfaces. Use of commercial software packages for design and analysis, optimization.

Texts:
1. G. F. Hewitt, G L Shires and T R Bott, Process Heat Transfer, CRC Press, 1994.
2. Kakac, H Liu, Heat Exchangers, CRC Press, 2002.

References:
1. Yonous A. Cengel, Heat transfer: A Practical Approach, McGraw Hill, 2002.
2. Thomas Lestina and Robert Serth, Process Heat Transfer, Principles and Applications, Academic Press, 2007.
3. R. K. Shah and D P Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons., 2003.
4. Tubular Exchanger Manufacturers Association, Inc, Standards of Tubular Exchanger Manufacturers Association, 1968.
5. Sarit K. Das, Process Heat Transfer, Narosa Publishing House, 2005.
6. W. M. Kays, A. L. London, Compact Heat Exchangers, Krieger Pub Co, 1998.

ME572 ADVANCED THERMAL STORAGE TECHNOLOGIES (3-0-0-6)

INTRODUCTION-Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

SENSIBLE HEAT STORAGE SYSTEM-Basic concepts and modelling of heat storage units - modelling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

REGENERATORS- Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

LATENT HEAT STORAGE SYSTEMS- Modelling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

APPLICATIONS- Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries

Texts:
1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2011.

References:

1.Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

2. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

ME574 HEAT TRANSFER APPLICATIONS (3-0-0-6)

Design, including experimental and numerical analysis, of heat transfer devices/systems related to a wide variety of applications, such as, energy conversion, food processing, manufacturing, solar energy, electronic and electrical equipment cooling, microscale heat transfer, heat sinks, heat exchangers, heat pipes, biomedical applications, measurements and instrumentation, amongst others. The tasks will involve fabrication and experimental measurements.

Texts:

1. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine, Principles of Heat and Mass Transfer, John Wiley & Sons, 2012.
2. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press; 2010.

References:

1. Granger R. A., Experiments in heat transfer and thermodynamics, Cambridge University Press, 2000.
2. Biomedical applications of heat and mass transfer, R. C. Seagrave, Iowa State University Press, 1971.
3. M. V. C. Sastri, B. Viswanathan and S. S. Murthy, Metal Hydrides, Narosa Publishing House, 1998.
4. Yang Wen-Jei, Mochizuki S. and Nishiwaki N., Transport Phenomena in Manufacturing and Materials processing, Elsevier, 1994.
5. Zumbrunnen D. A., Heat and Mass Transfer in Materials Processing and Manufacturing,ASME, New Orleans, 1993.
6. Bejan A. And Kraus A. D., Heat Transfer Handbook,Wiley& Sons, Inc. 2003.

ME576 TWO PHASE FLOW HEAT TRANSFER (3-0-0-6)

Formulation and Solution to Phase Change Problem, Two Phase Flow Fundamentals, Review of one-dimensional conservation equations in single phase flows; Governing equations for homogeneous, separated and drift-flux models; Flow pattern maps for horizontal and vertical systems; Simplified treatment of stratified, bubbly, slug and annular flows. Modelling of Two-Phase Flow, Pressure Drop in Two-Phase Flow, Brief Discussion on Critical Flow and Unsteady Flow. Description and Classification of Boiling, Pool Boiling Curve, Nucleation and Dynamics of Single Bubbles, Heat Transfer Mechanisms in Nucleate Boiling, Nucleate Boiling Correlations, Hydrodynamic of Pool Boiling Process, Pool Boiling Crisis, Film Boiling Fundamentals, Flow Boiling, Forced-Flow Boiling Regimes, Flow Boiling Curves, Nucleate Boiling in Flow, Sub-cooled Nucleate Flow Boiling, Saturated Nucleate Flow Boiling, Flow Boiling Correlations, Flow Boiling Crisis. Condensation- Film and dropwise condensation.

Texts:

1. S. Mostafa Ghiaasiaan, Two-Phase Flow, Boiling And Condensation in Conventional and Miniature Systems, Cambridge University Press, 2008.
2. L. S. Tong and Y. S. Tang, Boiling Heat Transfer and Two-Phase Flow, Taylor and Francis, 1997

3. J. B. Collier, and J. R. Thome, Convective boiling and condensation, Oxford Science Publications, 1994.

References:

1. C. Kleinstreuer, Two-Phase Flow: Theory and Applications, Taylor & Francis, 2003.
2. G.B. Wallis, One-Dimensional Two-Phase Flow, McGraw-Hill, 1969.
3. P B Whalley, Boiling, Condensation and Gas-Liquid Flow. Oxford University Press, 1987.

ME578 **FIRE DYNAMICS AND ENGINEERING** **(3-0-0-6)**

Basics of conservation equations, turbulence, radiation and thermochemistry. Ignition of solids–burning and heat release rates. Properties of fire plumes–buoyant plumes and interactions with surfaces. Turbulent diffusion flames–structure, modeling, soot formation and radiation effects. Toxic products. Fire chemistry, thermal decomposition of bulk fuel, pyrolysis, nitrogen and halogen chemistry. Fire growth– ignition, initial conditions, flame and fire spread theory, feedback to fuel. Compartment zone models. Flashover, post-flashover and control. Fire detection, suppression methods, codes, standards and laws. Case studies of real fires–buildings, transport, industries, forests, shamiana, jhuggi-jhonpdi.

Texts:

1. Quintiere J. G., Fundamentals of Fire Phenomena, John Wiley & Sons, Chichester, UK, 2011.
2. Drysdale D., An Introduction to Fire Dynamics, John Wiley & Sons, UK, 2011.
3. Karlsson B. and Quintiere J. G., Enclosure Fire, CRC Press, 2000.

References:

1. Turns S. R., An Introduction to Combustion, McGraw-Hill, New York, USA, 2012.
2. The SFPE Handbook of Fire Protection Engineering, 2nd Ed., 1995.