BIJU PATNAIK UNIVERSITY OF TECHNOLOGY, ODISHA
ROURKELA

Mechanical Engineering

M. Tech (THERMAL AND FLUID ENGINEERING)

SEMESTER- I

Code No.	Course Title	L	T	P	C
THEORY					
	Professional Core				
TFPC101	Advanced Fluid Mechanics	3	1	0	4
TFPC102	Advanced Heat Transfer – I (Conduction & Radiation)	3	1	0	4
TFPC103	Computational Fluid Dynamics	3	1	0	4
	Professional Electives -I (Any one)				
TFPE101	Advanced Refrigeration Engineering	3	1	0	3
TFPE102	Energy Conservation and Management	3	1	0	3
TFPE103	Gas Dynamics	3	1	0	3
	Professional Electives –II (Any one)				
TFPE104	Solar Energy Technology	3	1	0	3
TFPE105	Gas Turbine and Jet Propulsion	3	1	0	3
TFPE106	Numerical Methods For Thermal Radiation Heat Transfer	3	1	0	3
Sessional / Practical					
TFPR101	Engineering Software Laboratory	0	0	3	2
TFPR102	Thermal Engineering Laboratory	0	0	3	2
TFPT101	Pre-Thesis work and Seminar				2
	Total Credit -24				

SEMESTER- II

Code No.	Course Title	L	T	P	C
THEORY					
	Professional Core				
TFPC201	Advanced Engineering Thermodynamics	3	1	0	4
TFPC202	Advanced Heat Transfer – II (Convective Heat and Mass Transfer)	3	1	0	4
	Professional Electives -III (Any one)				
TFPE201	Computational Methods in Thermal Engineering	3	0	0	3
TFPE202	Experimental Methods in Thermal Engineering	3	0	0	3
TFPE203	Heat Exchanger Analysis and Design	3	0	0	3
	Professional Electives –I V (Any one)				
TFPE204	Internal Combustion Engine	3	0	0	3
TFPE205	Aircraft and Rocket Propulsion	3	0	0	3
TFPE206	Two Phase Flow and Heat Transfer				
	Professional Electives –V (Any one)				
TFPE207	Cryogenic Technology	3	0	0	3
TFPE208	Wind Energy Conversion	3	0	0	3
TFPE209	Viscous Fluid Flow	3	0	0	3
Sessional / Practical					
TFPR201	Advanced Thermal Engg. and Measurement Lab.	0	0	3	2
TFPR202	Elective Laboratory (CFD Laboratory)	0	0	3	2
TFPT201	Pre-thesis work and seminar				2
TFCV201	Comprehensive Viva-Voce				2
	Total Credit -25				

TFPC101 ADVANCED FLUID MECHANICS

Module I

Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential.

Module II

Transport theorems, constitutive equations, derivation of Navier Stokes equations for compressible flow. Exact solutions of Navier Stokes equations : plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stoke's first and second problem, Hiemenz flow, flow near a rotating disk, flow in convergent- divergent channels. Slow viscous flow : Stokes and Oseen's approximation,

Module III

Theory of hydrodynamic lubrication. Boundary layer : derivation, exact solutions, Blasius, Falkner Skan, series solution and numerical solutions. Approximate methods. Momentum integral method. Two dimensional and axisymmetric jets. Description of turbulent flow, velocity correlations, Reynold's stresses, Prandtl's Mixing Length Theory, Karman's velocity defect law, universal velocity distribution.

Books:

1. Advanced Fluid Mechanics, Som and Biswas, Tata McGraw Hill
2. Fluid Mechanics, A.K.Mohanty
3. Fundamentals of Fluid Mechanics, Schlitching
4. Introduction to Fluid Mechanics, Shaughnessy, Oxford University Press

TFPC102 ADVANCED HEAT TRANSFER–I
(Conduction & Radiation)

Module I

Conduction; Derivation of generalized conduction equation for anisotropic inhomogeneous solids, conductive tensor, concepts of isotropic and homogeneous conductivity. ; Steady state conduction: Recapitulation of fundamentals analysis and design variable and cross section and circumferential fins. Analysis of heat conduction in 2-D fins, 2-D and 3-D conduction in solids with complex boundary conditions and heat generation. ;

Module II

Transient conduction: Recapitulation of transient conduction in simple systems. Analysis of transient heat conduction with complex boundary. ; Application of Duhamel's theorem and Special topics: Use of lap- lace transformation in linear conduction problems. The use of green function in the solution of the equations of conduction. ; Numerical methods: Fundamentals of discrimination treatment of boundary conditions, on linearity of properties, anisotropy and complex boundaries.

Module III

Radiation ; Recapitulation of fundamentals of radiative heat transfer, radiative properties of surfaces, methods of estimating configuration factors, heat exchange between diffusively emitting and diffusively reflecting surfaces. Convective heat transfer of particles by cavitation effect due to ultrasonic frequency, Radiant energy transfer through absorbing, emitting and scattering media. Combined conduction and radiation systems: fins, Introduction to solar radiation in earth's atmosphere.

Books

1. V.S Arpaci – Conduction Heat Transfer
2. E.M Sparrow, R.D Cess – Radiation Heat Transf
3. R.Siegal and J.R Howell-Thermal radiation heat transfer.
4. Y.A.Sengel, Heat Transfer, Tata McGrawHill
5. Krith, Fundamentals of Heat Transfer
6. Ozisik, Heat Transfer, John Wiley

TFPC103 COMPUTATIONAL FLUID DYNAMICS

Introduction: Basic tools of CFD, Numerical Vs experimental tools. ; Mathematical Behavior of PDEs: Parabolic, Hyperbolic and Elliptic PDEs. ; Methodology of CFDHT: Discrete representation of flow and heat transfer domain: Grid generation, Governing equations and boundary conditions based on FVM/FDM, Solution of resulting set of linear algebraic equations, Graphical representation and analysis of qualitative results, Error analysis in discretization using FVM/FDM. ; Solution of 1-D/2-D steady/unsteady: Diffusion problems, Convection problems, Convection-diffusion problems, source term linearization. ; Explicit and Implicit Approach: Explicit and implicit formulation of unsteady problems, Stability analysis. ; Solution of Navier-Stokes Equations for Incompressible Flows: Staggered and collocated grid system, SIMPLE and SIMPLER algorithms. ; Special Topics in CFDHT: Numerical Methodology for Complex Geometry, Multi-block structured grid system, Solution of phase change Problems. Particle dispersion technique and its tracking by ultrasonic dispersion method.

Essential Reading:

1. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis, ISBN-10: 089116522

Supplementary Reading:

1. H. K. Versteeg and W. Malalasekra, Introduction to Computational Fluid Dynamics: The Finite Volume Method, Prentice Hall (2nd Edition), ISBN-10: 0131274988.
2. Jr. D. A. Anderson, Computational Fluid Mechanics and Heat Transfer by McGraw-Hill Education
3. M. N. Ozisik, Finite Difference Method, CRC (1st Edition).

ELECTIVE - I

TFPE101 ADVANCED REFRIGERATION ENGINEERING

Module I

Analysis of refrigeration cycle, principles of psychrometry properties and processes, Air washer, Cooling towers, dehumidifiers, wet bulb and dew point temperatures. Multistage cycle and their optimization.

Module II

Thermodynamic Properties of pure and mixed refrigerants. Eco-friendly Refrigerants, vapour absorption cycle and its components. Ejector Refrigeration System, Vortex Tubes, Principle of liquefaction of gases, Dry ice manufacture, Magnetic Refrigeration Sysem

Module III

Analysis and thermal design of Refrigeration compressor, condenser, evaporator and flow control devices; Design, Lubrication, charging and testing of refrigeration plants, defrosting capacity control, system component balancing, Design and construction details of unitary refrigeration equipment.

Books

1. Refrigeration and Air Conditioning, C.P.Arora, Tata McGraw Hill
2. Refrigeration and Air Conditioning, Stoecker and Zones, McGraw Hill
3. Refrigeration and Air Conditioning, Domkundwar and Arora, Dhanpat Rai and Sons
4. Refrigeration and Air Conditioning, Manohar Prasad, East West Press
5. Refrigeration and Air Conditioning, P.L.Balaney

TFPE102 ENERGY CONSERVATION AND MANAGEMENT

Module I

Significance and Scope of Energy conservation and Management, Basic principles and total energy concept, First law optimization, availability. Exergy analysis. Second law optimization of thermal systems.

Module II

Energy audits and conservation programme, elements of energy accounting. Plant energy studies : concepts, resources, procedures and implementation. Energy accounting indices, energy budget and variance analysis- statistical and engineering models. Economic aspects, payback. Waste Heat recovery; high, medium and low temperature applications, Methods of energy conservation in domestic and industrial sectors; case studies

Module III

Energy sources, Classification and characterization of fuels (fossil and bio-fuel), conversion and utilization, environmental and economic issues, optimum use of energy resources, Thermodynamic cycles, Principles of thermal energy conversion in boilers, internal combustion engines and gas turbines, cogeneration and combined cycle power generation, fuel cells and MHD technology, solar, wind and nuclear power, utilization of industrial heat, Energy management in industry, Environmental and economic evaluation advanced pollution control technology.

Books

1. R. Gold Stick and A. Thumann, Principles of Waste Heat Recovery, PHI, 1986.
2. D. Y. Goswami, F. Kreith, Energy Conversion- CRC Press, 2007
3. V. Kadambi, and M. Prasad, Introduction to energy conversion turbo machinery: Energy conversion cycle- Wiley Eastern, New Delhi, 1974,

TFPE103 GAS DYNAMICS

Module I:

Fundamental Aspects of Gas Dynamics: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations ; Normal Shock Waves: Shock waves, stationary normal shock waves, normal shock wave relations in terms of Mach number;

Module II:

Oblique Shock Waves: Oblique shock wave relations, reflection of oblique shock waves, interaction of oblique shock waves, conical shock waves; Expansion Waves: Prandtl-Meyer flow, reflection and interaction of expansion waves, flow over bodies involving shock and expansion waves ; Variable Area Flow: Equations for variable area flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers ; Adaiabatic Flow in a Duct with Friction: Flow in a constant area duct, friction factor variations, the Fanno line ;

Module III:

Flow with Heat addition or removal: One-dimensional flow in a constant area duct neglecting viscosity, variable area flow with heat addition, one-dimensional constant area flow with both heat exchanger and friction ; Generalized Quasi-One-Dimensional Flow: Governing equations and influence coefficients, solution procedure for generalized flow with and without sonic point ; Two-Dimensional Compressible Flow: Governing equations, vorticity considerations, the velocity potential, linearized solutions, linearized subsonic flow, linearized supersonic flow, method of characteristics.

Essential Reading:

1. L. D. Landau and E. M. Lifshitz, Fluid Mechanics. 2nd ed., Butterworth-Heinemann, 1995.
2. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001.

Supplementary Reading:

1. P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 1997.
2. M. A. Saad, Compressible Fluid Flow. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1993.
3. F. M. White, Viscous Fluid Flow. 2nd ed. New York: McGraw-Hill, 1991.
4. A. H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.

ELECTIVE II

TFPE104 SOLAR ENERGY TECHNOLOGY

Module I

Current alternate energy sources-thermodynamic view point and conversion methods. Components of solar energy systems, collector performance. Radiation and meteorological data processing, long term conversion factors. System configurations and system performance prediction.

Module II

Simulations, design methods. System design and optimizations. Solar thermal systems applications to power generation, heating and cooling.

Module III

Solar passive devices solar stills, ponds, greenhouse, dryers. Trombe wall, overhangs and winged walls. Wind energy conversion systems. Economics of solar and wind energy systems.

Books

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
4. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
5. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London,1986.

TFPE105 GAS TURBINE & JET PROPULSION

Introduction, application, shaft power gas dynamics – Compressibility effect, steady one dimensional compressible flow of a perfect gas in a duct, isentropic flow in a constant area duct with friction, normal shock waves, oblique shock wave, isentropic two dimensional, supersonic expansion and compression. ; Centrifugal fans Blowers and Compressors: Principle of operations, work done and pressure rise, slip factor, diffusers, compressibility effects, non dimensional qualities for plotting compressor characteristics. Bray ton cycle, regeneration and reheating cycle analysis ; Axial flow fans and compressors: Elementary theory, degree of reaction, three dimensional flow, simple design methods, blade design, calculation of stage performance, overall performance, and compressibility effects. Performance characteristics. ; Combustion system: Form of combustion, important factors affecting combustion chamber design, combustion processes, combustion chamber performance, practical problem. ; Axial flow turbines: elementary theory, vortex theory, choice of blade profile, pitch and chord ; estimation of stage performance, he cooled turbine. ; Prediction of performance of simple gas turbines: component characteristic, off design shaft gas turbine, equilibrium running gas generators, off design o free turbine and jet engine, methods of displacing the equilibrium, running line, incorporation of variable pressure losses, methods of improving part load performance, matching procedure for twin spool engines, behavior of gas turbine .Gas turbine rotors and stresses.

Books:

1. J.E Lee, Theory and design of stream and gas turbine.
2. Cohen & Rogers, Gas Turbines

TFPE106 NUMERICAL METHODS FOR THERMAL RADIATION HEAT TRANSFER

Fundamentals of thermal radiation; Radiative transfer without participating media; Radiative transfer with participating media; Governing equations in radiative transfer analysis with participating media; Methods for solving radiative transfer problems - analytic method, Monte Carlo method, zonal method, flux method, P-N approximation, discrete ordinate method, finite element method, discrete transfer method, finite volumet method, collapsed dimension method. Application of numerical methods for solving conjugate radiation, conduction and/or convection problems in 1-D and 2-D Cartesian and axi-symmetric geometry.

Books:

1. R. Siegel and J. R. Howell, *Thermal Radiation Heat Transfer*, 3rd edition, Taylor and Francis, 1992.
2. M. F. Modest, *Radiative Heat Transfer*, McGraw-Hill, 1993.
3. M. N. Ozisik, *Radiative Transfer and Interactions with Conduction and Convection*, John Wiley & Sons, 1973.

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2nd Semester

TFPC201 ADVANCED ENGINEERING THERMODYNAMICS

Review of Basics: First law and Second law analysis – concept of entropy – principle of increase of entropy – entropy generation – Availability – concept of exergy – exergy analysis of combustion processes. Helm Holtz function – Gibb's function – OnSagar reciprocity relation. Thermodynamic relations, Maxwell's relations, T-ds equations – specific heat relations – energy equation – Joule Thomson effect – Clausius Claperyon Equation. Criteria for Equilibrium – Gibb's phase rule – Conditions for stability. Compressibility factor, fugacity and activity, computation from the generalized charts, dependence of fugacity and activity on pressure and temperature, chemical – equilibrium. Phase rule – ideal and real solution of gases, liquids, equilibrium system. Statistical Thermodynamics: Thermodynamics probability, Maxwell statistics, Fermi Dirac and Bose – Einstein statistics, Entropy and probability, Degeneracy of energy levels, Partition functions. Kinetic Theory of Gases: Perfect gas model, Distribution of translational velocities distribution function, molecular collisions and mean free path, equipartition of energy.

Essential Readings:

1. A.S. Michael, 'Thermodynamic for Engineers', Prentice Hall, 1972.
2. P.K. Nag., 'Engineering Thermodynamics', II Ed., McGraw Hill, 1995.

Supplementary Reading:

1. G.J. Van Wylen & R.E. Sonntag., 'Fundamentals of Classical Thermodynamics', Willy Eastern Ltd. 1989 (Unit I, II & III)
2. J.P. Holman., 'Thermodynamics', 4th Ed., McGraw Hill, 1988.
3. J. Hsieg, 'Principles of Thermodynamics', McGraw Hill, 1978.
4. Lee and Sears, 'Statistical Thermodynamics', Addition Wesley, 1976.
5. V. Nastrand, S. Glasstne., ‗Thermodynamics for Chemists', 1974.
6. M.D. Burghardt, 'Engineering Thermodynamics for Engineers', Harper and Row, NY, 1987.
7. K. Wark, 'Advanced Thermodynamics for Engineers', McGraw Hill, NY, 1987.

TFPC202 ADVANCED HEAT TRANSFER-II
(Convective Heat & Mass Transfer)

Convection: Energy equation – thermal boundary layer. Forced convection – Practical correlations –flow over surfaces – internal flow. Natural convection, combined forced and free convection combined convection and radiation in flows. ; Boiling and Condensation: Boiling – Pool and flow boiling, correlations. Condensation – modes and mechanisms – correlations and problems. Heat Exchangers: Heat Exchanger and Mass Transfer -Heat exchanger: types – LMTD method and the effectiveness – NTU method. Mass Transfer: types – Fick‘s law of diffusion – mass diffusion equation, Equimolar counter diffusion – convective mass transfer. Evaporation of water into air.

Essential Readings:

1. J.P. Holman., 'Heat and Mass Transfer', Tata McGraw Hill, 8th Ed., 1989.
2. D.D. Kern, 'Extended Surface Heat Transfer', New Age International Ltd., 1985.

Supplementary Reading:

1. F.P. Incropera and D. P. Dewit, ‗Fundamentals of Heat and Mass Transfer', 4th Ed., John
2. Wiley & Sons, 1998.
3. C. P. Kothandaraman., ‗Fundamentals of Heat and Mass Transfer', 2nd Ed., New Age International, 1997.
4. E.R.D Eckert and R.M. Drake, ‗Analysis of Heat and Mass Transfer', McGraw Hill, 1980.
5. Kays, W.M. and Crawford W., ‗Convective Heat and Mass Transfer', McGraw Hill Inc., 1993.
6. Burmister L.C., 'Convective Heat Transfer', John Willey and Sons, 1983.

Electives –III (Any One)

TFPE201 COMPUTATIONAL METHODS IN THERMAL ENGINEERING

Introduction: Concepts of consistency, stability, and convergence of numerical schemes. Various finite difference and finite element methods and their applications to fundamental partial differential equations in engineering and applied sciences. Case studies selected from fluid mechanics and heat transfer. ; Finite Difference Method: Classification, Initial and Boundary conditions, Forward, Backward difference, Uniform and non-uniform Grids, Grid Independence Test. Basic finite difference schemes. Boundary treatments. Fourth order RK methods and Predictor-corrector methods and Nachsheim-Swigert iteration with applications to flow and heat transfer. ; Parabolic and hyperbolic problems: Model problems and stability estimates. Examples of the methods of lines. The Lax-Richtmyer equivalence theorem. Stability analysis. Discrete Fourier series. Von- Neumann stability analysis. Consistency, convergence and error estimates. Keller Box and Smith‘s method with applications to thermal boundary layers. ; Convection dominated problems: The failure of standard discretization, Upwinding and Higher order methods.

Books:

1. K.Muralidhar and T.Sundararajan, "Computational Fluid Flow and Heat Transfer", Narosa Publishing House ,New Delhi1995.
2. P.S., Ghoshdasdidar, "Computer Simulation of flow and heat transfer" TMH Ltd., 1998.
3. S.V. Patankar, "Numerical heat transfer fluid flow", Hemisphere Publishing Co, 1980.
4. D.A. Anderson, I.I. Tannehill, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Hemishphere Publishing Corporation, New York, USA, 1984.
5. C.A.J. Fletcher, ,"Computational Techniques for Fluid Dynamics
6. Fundamental and General Techniques, Springer-Verlag,1987.
7. T.K. Bose, "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

TFPE202 EXPERIMENTAL METHODS IN THERMAL ENGINEERING

Theory and Experimentation in Engineering: Problem solving approaches, Types of engineering experiments, computer simulation and physical experimentation; Generalized measuring system, types of inputs, analog and digital signals, standards, calibration and uncertainty, Measurement System: Performance characteristics, static performance characteristics-static calibration-linearity, static sensitivity, repeatability, hysteresis- threshold- resolution, readability and span; Analysis of Experimental Data : Causes and types of experimental error, un-certainty analysis, statistical analysis of data, probability distributions and curve fitting; Dynamic performance characteristics; Input types; Instrument types- zero order instrument, first order instrument, second order instrument; Experiment Plans: Model building; Measurement Methods and Applications : Measurement of force and torque; Measurement of strain and stress; Measurement of pressure; Flow measurement and flow visualization; measurement of temperature; optical methods of measurements; Data Acquisition and Processing : Types and configurations of DAS, signal conditioning, A/D, D/A conversion; Design, Planning, Execution and Analysis of experimental projects.

Books:

1. Beckwith, Buck, and Marangoni, *Mechanical Measurements*, Narosa Publishing House, 1995.
2. Doeblin, *Measurement Systems - Application and Design*, 4e, McGraw-Hill, 1990.
3. Holman, *Experimental Methods for Engineers*, 6e, McGraw-Hill, 1994.
4. Doeblin, *Engineering Experimentation*, McGraw-Hill, 1995.

TFPE203 HEAT EXCHANGER ANALYSIS & DESIGN

Constructional Details: Types, Fluid flow arrangements, parallel, counter and cross flow, shell and tube heat exchanger, Regenerators and recuperator. Condensers – Industrial applications. ; Heat Transfer: Modes of Heat Transfer, Overall heat transfer coefficient, Thermal resistance, Efficiency. Temperature Distribution and its implications, LMTD, effectiveness ; Flow Distribution: Effect of Turbulence, Friction Factor, Pressure Loss, Orifice, Flow nozzle, Diffusers, Bends, Baffles, Effect of Channei Divergence, Manifolds. ; Stress in tubes, Headers sets and Pressure vessels: Differential Thermal Expansion, Thermal stresses, Shear stresses, Thermal sleeves, Vibration, Noise, types of failures. ; Design Aspects: Heat transfer and pressure loss flow configuration effect of baffles. Effect of deviations from ideality. Design of typical liquid-liquid, gas-gas-liquid heat exchangers. Design of cooling towers.

Essential Reading:

1. W.M. Kays and A.L. London., ‗Compact Heat Exchangers', 3rd Ed., TMH,1984.
2. A.P. Frass and M.N.Ozisik, Heat Exchanger Design',John Wiley & Sons Inc, 1965.
3. G.Wlker, ‗Industrial Heat Exchangers', A basic guide, TMH V Book Co., 1980.

Supplementary Reading:

1. 'Standards of the Turbular Exchanger Manufacturer Association', 6th Ed., Tubular Exchanger Manufacturers Association, New York, 1978.
2. D. Q Kern, ‗Process Heat Transfer', McGraw Hill Book Co., 1984.
3. E.A.D. Saunders., ‗Heat Exchangers', Longman Scientific and Technical, New York, 1988.

Electives –IV (Any One)

TFPE204 INTERNAL COMBUSTION ENGINES

Module I

Thermodynamic Analysis of I.C.Engine Cycles. Effect of design and operating parameters on cycle efficiency. Modified fuel-air cycle considering heat losses and valve timing. Engine dynamics and torque analysis. Use of Combustion chart . Thermodynamic cycle with supercharging both S.I. and C.I. Engines. Limits of Supercharging. Methods of Supercharging and Superchargers.

Module II

Fuels and combustion in S.I. engines, knocking and fuel rating. Energy balance, volumetric efficiency, measurement of indicated and brake power. Advanced theory of carburetion. Fuel Injection Systems for S.I. and C.I. Engines. Cooling of engine and governing of engine. Ignition system : conventional and electronic.

Module III

Variable compression ratio engine. Theoretical analysis, methods of obtaining variable compression ratio, Wankel rotary combustion engine, Stratified charged engine, Methods of charge stratification, Dual fuel and Multifuel engines, Biofuels, Variable Valve timing engines, Exhaust emissions, its measurement and control. Fault diagnosis of S.I. Engines.

Books

1. Fundamentals of I.C. Engines by H.B.Heywood, McGraw Hill
2. I.C.Engine Theory and Practices, Vol.I & II C.F.Taylor, MIT Press
3. I.C.Engine, Mathur and Sharma, Dhanpat Rai and Sons
4. Fundamentals of I.C.Engine by Ganeshan, Tata McGraw Hill

TFPE205 AIRCRAFT & ROCKET PROPULSION

Introduction, Rocket system and aerodynamics of rockets, Fundamentals of gas turbine engines, Illustration of working principles of gas turbine engine, Propulsion system and operating principle, Thermodynamics of propulsion system, Engine performance parameters, The ramjet cycle, Working principles of ideal ramjet cycle, The turbojet cycle, Working principles of turbojet cycle, Non-ideal turbojet cycle, Axial flow fans and compressors, Polytrophic efficiency of compression, Calculation of stage performance and overall performance, Working principles of turbofan cycle, Rocket performance, Introduction and working principles of multistage rocket, Solid propellant rockets, Liquid propellant rockets ,Thrust control in liquid rockets Cooling in liquid rockets, Hybrid rockets, Limitations of hybrid rockets, Relative advantages of liquid rockets over solid rockets

Books:

1. G.C. Oates, Aerothermodynamics of Aircraft Engine Components, AIAA Education Series, New York, 1985.
2. W.W. Bathie, Fundamentals of Gas Turbines- John Wiley & Sons, 1984.
3. M.L. Mathur, and R.P. Sharma, Gas Turbine Jet and Rocket Propulsion, Standard Publishers and Distributors, Delhi, 1988.
4. P.G. Hill, Mechanics and Thermodynamics of Propulsion- Addison Wesley, 1970.
5. S.M. Yahya, Fundamentals of Compressible Flow - John Wiley, New York, 1982.
6. A.K. Mohanty, Fluid Mechanics - Prentice Hall, New Delhi, 2003.

TFPE206 TWO-PHASE FLOW AND HEAT TRANSFER

Definitions; 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.

Thermodynamics of boiling; Pool boiling- onset of nucleation, heat transfer coefficients, critical heat flux, effect of sub-cooling; Flow boiling- onset of nucleation, heat transfer coefficients, critical heat flux, effect of sub-cooling.

Condensation- Film and dropwise condensation

Books:

1. Wallis, G.B., *One dimensional two-phase flows*, McGraw-Hill 1969.
2. Collier, J.B. and Thome, J.R., *Convective boiling and condensation*, Oxford Science Publications, 1994.
3. L S Tong and Y S Tang. *Boiling Heat Transfer and Two-Phase Flow*. Taylor and Francis, 1997.
4. P B Whalley. *Boiling, Condensation and Gas-Liquid Flow.* Oxford University Press, 1987.

Electives –V (Any One)

TFPE207 CRYOGENIC TECHNOLOGY

Introduction: Cryogenic heat transfer applications, Material Properties at cryogenic temperatures, specific heats and thermal conductivity of solid, liquid and gases, Cryogenic insulations, gas-filled and evacuated powders and fibrous materials, microsphere and multi-layer insulations. ; Conduction: One-dimensional steady-state and transient conduction, conduction in composite materials, thermal contact resistance, cool-down in coated surfaces and fluid-storage vessels. ; Convection: Free and forced convection over external surfaces and tubes, Heat transfer in nearcritical region and its correlations, Kapitza conductance. ; Two-Phase Heat Transfer: Flow regimes, pressure drop, Lockhart-Martinelli correlation, pool boiling, forced convection boiling. ; Radiation: Radiation from LNG fires, free-molecular flow and heat transfer, free-molecular heat transfer in enclosures. ; Heat Exchanger: Cryogenic heat exchanger types, NTU-effectiveness design method, Giauque- Hampson design, Plate-fin and perforated-plate heat exchanger design, effect of variable specific heat, effect of longitudinal heat conduction, effect of heat transfer from ambient, Regenerators, Regenerator design.

Essential Reading:

1. R.F. Barron, ‗Cryogenic Systems', McGraw Hill, 1985.
2. R.B. Scott, ‗Cryogenics Engineering', Van Nostrand & Co., 1962.

Supplementary Reading:

1. H. Weinstock, ‗Cryogenic Technology', 1969.
2. K. D. Timmerhaus and T. M. Flynn., ‗Cryogenic Process Engineering', Plenum Press, New York, 1989.
3. R. W. Vance., ‗Cryogenic Technology', John Wiley & Sons Inc., New York, London, 1971.
4. Sengapatha, A. Bose, ‗Cryogenics – Progress and Applications', Tata McGraw Hill,1987.

TFPE208 WIND ENERGY CONVERSION

Sources and characteristics of wind, selection of site, wind resource assessment, power in the wind; classification of wind turbines, horizontal and vertical axis wind turbines, wind turbine aerodynamics, applications-wind diesel systems, wind farms, wind pumps and offshore wind turbines; turbine airfoils and rotor wakes, operational characteristics; structural considerations, wind turbine acoustics, electric power systems, economic assessment, environmental and social issues.

Books:

1. J F Walker, and N Jenkins, *Wind Energy Technology*, John Wiley and Sons, 1997.
2. D A Spera, (Ed.), *Wind Turbine Technology*, ASME, 1994.
3. N G Calvert, *Windpower Principles: Their Application on the Small Scale*, London, Griffin, 1978.
4. F R Eldridge, *Wind Machines*, NY: Von Nostrand Reinhold, 1980.
5. D M Eggleston, and F S Stoddard, *Wind Turbine Engg. Design*, Von Nostrand, New York, 1987.
6. L L Freris, (Ed.), *Wind Energy Conversion Systems,* Prentice Hall, London, 1990.
7. D M Simmons, *Wind Power*, Noyes Data Corp. New Jersey, 1975.

TFPE209 VISCOUS FLUID FLOW

Preliminary concepts; Conservation of mass, momentum and energy; Exact solutions of the viscous flow equations: Couette flows, Poiseuille flow through ducts, unsteady duct flows; Laminar boundary-layers: integral analysis and similarity solutions; Laminar free shear flows: jet, wake, and plume; Stability of laminar flows; Turbulent flow: fundamentals, Reynolds-averaged equations, velocity profile in wall-bounded flows, turbulent flow in pipes and channels, turbulent free-shear flows (jet, wake, and plume); Turbulence modelling: zero, one, and two equation models of turbulence; Numerical methods.

Books:

1. Frank M White, *Viscous Fluid Flow*, McGraw-Hill, 1991.
2. Schlichting and Gersten. *Boundary-Layer Theory*. Springer-Verlag, 2000.
3. F S Sherman, *Viscous Flow*, McGraw-Hill, 1990.