DEPARTMENT OF MECHANICAL ENGINEERING
BIRLA INSTITUTE OF TECHNOLOGY
MESRA, RANCHI
Courses of Studies for M.E. Programme in Heat Power

		L	T	P	C
I Semester:					
(Theory Courses)					
MME 1001 Advanced Fluid Mechanics		3.0	-	-	3.0
MME 1003 Heat and Mass Transfer		3.0	-	-	3.0
MMA 1103 Advanced Mathematics		3.0	1.0	-	4.0
Elective - any one					
MME 1005 Turbomachines		3.0	-	-	3.0
MME 1009 Computational Methods in Thermal Engineering					
MME 1013 Design of Thermal System					
MME 1011 Theory and Design of I.C. Engines					
Breadth Subject any one		3.0	-	-	3.0
Sessional:					
MME 1002 Fluid Mechanics Laboratory		-	-	3.0	2.0
MME 1004 Elective Course Work		-	-	3.0	2.0
	Total				**20.00**
II Semester:					
(Theory Courses)					
MME 2001 Advanced Thermodynamics		3.0	-	-	3.0
MME 2013 Refrigeration and Air Conditioning		3.0	-	1.0	4.0
MME 2011 Gas Turbine and Jet Propulsion		3.0	-	-	3.0
Advanced Engineering Science					
MME 2005 Fuels and Combustion		3.0	-	-	3.0
Breadth Subject: any one					
		3.0	-	-	3.0
Sessional					
MME 2002 Solar Energy Laboratory		-	-	3.0	2.0
MME 2004 Heat Transfer Laboratory		-	-	3.0	2.0
		Total :			**20.0**
III Semester:					
1. Thesis					**15.0**
IV Semester:					
1. Thesis					**20.0**
Grand Total					**75.00**

MME 1001: ADVANCED FLUID MECHANICS

MODULE- I

Description of fluid motion: Euler and Lagrangian description. Reynold's Transport theorem, rate of linear and angular strain, Mass, momentum and energy equations, Stream function and velocity potential function and its application. (5L)

MODULE-II

Navier-Stokes Equation: Derivation of Navier-Stokes equation, Exact solution of Navier-Stokes equations: Hagen-Poiseuille flow and Coutte flow, Flow between two rotating cylinders. Stokes first and second problem. (5L)

MODULE-III

Boundary Layer: Blasius equation, Momentum integral and similarity techniques, Solution of boundary layer equations. Introduction to turbulent flow, Physical description of instabilities and turbulence, Reynold's averaging of N-S equation, Turbulent Boundary Layer over a flat plate. (5L)

MODULE-IV

Compressible flow: Review of fundamentals, One dimensional isotropic flow, Normal Shock relations, Stationary and moving shock waves, One dimensional diffusers. (5L)

Module-V

Oblique shock relations, Rankine-Hugoniot and Prandtl's equations. Working formulae, shock geometry, Shock polar diagram. (5L)

MODULE-VI

Flow in constant area duct with friction, Performance of long ducts and variation of pressure ratios, Chocking effects. Flow in duct with heating and cooling. (5L)

MODULE-VII

Two-dimensional subsonic flow with small perturbations, Linearization of the potential equation, Similarity laws. Hydrograph method for two-dimensional subsonic flow. (5L)

Books:

1. Fluid Mechanics by F.M. White.
2. Boundary Layer Theory by H. Schlichting.
3. Dynamics and Thermodynamics of Compressible flow by A.H. Shapiro.
4. Introductory Gas Dynamics by A.J. Chapman and W.F. Walker.
5. Fundamentals of Compressible flow by S.M. Yahya.

MME 1003 HEAT AND MASS TRANSFER

MODULE-I
Steady State Multidimensional Heat Conduction: Analytical, Graphical and numerical methods for solving heat transfer problems. (5L)

MODULE-II
Unsteady State Heat Conduction: Transient heat flow in a semi-infinite solid, sudden temperature change of the surface of a finite thick slab, unsteady state heat flow through semi infinite slab without surface resistance, multi dimensional transient heat flow system, Heisler charts for solving unsteady state problems, periodic heat flow. (5L)

MODULE-III
Equations of Convective Heat Transfer: Continuity and Navier-Strokes Equation, Energy Equation, similarity in convective heat transfer, vorticity and temperature fields, Equations for turbulent convective heat transfer, Boundary layer equations for laminar flow, Boundary layer equations for turbulent flow, boundary layer integral equation. (5L)

MODULE-IV
External Laminar Forced Convection: similarity and integral solutions of flow over isothermal and non-isothermal flat plate, Numerical solution of the laminar boundary layer flow over a flat plate and viscous dissipation effects on flow over a flat plate. (5L)

MODULE-V
Introduction to Turbulent Flows: governing equations, mixing length turbulence models, analogy solutions for heat transfer in turbulent flows, near walls region, transition from laminar to turbulent flow, analogy solution for boundary layer flows, numerical solution of turbulent boundary layer equations, viscous dissipation effects on turbulent boundary layer flow over a flat plate. (5L)

MODULE-VI
Radiation Heat Transfer: Shape factors of complicated geometries, use of graphs for finding shape factors, radiation between three gray bodies, radiation between gray cavity, radiation between hot gases and its enclosure, concept of radiation heat transfer coefficient, error calculation in the measurement of hot gas temperature, radiation through gases and vapours, radiation from flames. (5L)

MODULE-VII
Mass Transfer: Fick's law of diffusion; General equation of mass diffusion, mass transfer coefficient; convective mass transfer, mass transfer through boundary layer, analogy between momentum, heat and mass transfer; dimensional analysis of convective mass transfer. (5L)

Books:

1. Principles of Heat Transfer by Frank Kreith and Mark S. Bohn
2. Analytical Methods in Conduction Heat Transfer by Glen E. Mayers
3. Basic Heat and Mass Transfer by A. F. Mills.
4. Heat and Mass Transfer by J.P. Holman
5. A Text Book on Heat Transfer by S. P. Sukhatme

MME 1005: TURBOMACHINES

MODULE- I

Fundamental principles of turbomachines: Eulers equation, application to centrifugal machines, Axial flow pumps and turbines, Compressible flow theory, Shock wave effects, Cavitation, Illustrative examples of radial outflow machines, Axial pump and turbines, Example of a NPSE calculation. (5L)

MODULE-II

Centrifugal fan and blowers: Types, Centrifugal fan stage and design parameters, Drum and partial flow type fans, Losses, Fan bearings, Drives, Noise, Dust erosion of fans. (5L)

MODULE-III

Flow through cascades: Two-dimensional flow, Cascade of blades, Cascade tunnel, Axial turbine and compressor cascades, Annular and radial cascades. (5L)

MODULE-IV

Axial fans and propellers: Axial fans, Fan stage parameters, Types of axial fan stages, Propellers, Performance of axial fans. (5L)

Module-V

Three Dimensional flows in axial turbomachines: Theory of radial equilibrium, Compressible flow through fixed blade row, Constant specific mass flow, Off-design performance of a stage, Free vortex turbine stage, Actuator disc approach, Blade row interaction effects, Secondary flow. (5L)

MODULE-VI

Losses and Efficiency : Boundary layer losses, Flow separation, clearance and leakage losses, Windage losses, Partial admission losses, Secondary flow losses, Volumetric, Mechanical, hydraulic, Manometric and overall efficiencies, Diffuser, Nozzle and Blade efficiency; Mollier diagram for expansion and compression processes in turbine, compressor, Diffuser and nozzle; Total–to–total and Total–to–static efficiency, Polytropic efficiency, Cavitation, Stall, Surge and choking. (5L)

MODULE-VII

Dimension Analysis and Machine Performance : Dimensional analysis for incompressible and compressible flow turbomachines; Work-head and power coefficients; Mach number, Reynold's Number, Specific Speed and Cavitation parameter, Overall characteristics curves for pump, fan, Compressor and turbine, Similarity concept, Model study and scale effects. (5L)

Books:

1. Turbines Compressors and Fans by S. M. Yahya
2. Fluid Mechanics and Thermodynamics of Turbomachinery by S. L. Dixon
3. Turbomachines by V. KLadambi and Manohar Prasad.
4. Principles of Turbomachines by Turton.
5. Principles of Turbomachinery by D. G. Shepherd.

MME 1009: COMPUTATIONAL METHODS IN THERMAL ENGINEERING

MODULE- I
Overview of problems in thermal engineering, Backward , Forward and central differences, Interpolation formulas, Fourth order RK methods. (5L)

MODULE-II
Predictor-corrector methods and Nachsheim-Swigert iteration with application to tapered fin and other types of fin. (5L)

MODULE-III
Flow and heat transfer from flat plate and wedge (5L)

MODULE-IV
Stagnation point flow, Rotating disk and free convection from vertical flat plate. (5L)

Module-V
Round off error, Truncation error, Stability and convergence of algorithms. (5L)

MODULE-VI
Unsteady heat conduction equation and Laplace equation. (5L)

MODULE-VII
Keller box and Smith's method with applications to thermal boundary layers. (5L)

Books:

1. The CRC handbook of Thermal Engineering by Frank Kreith.
2. Computational methods in Environmental fluids by Olaf Kolditz.

MME 1013: DESIGN OF THERMAL SYSTEM

MODULE- I

Basic considerations in design: Formulation of the design problem, Conceptual design, Steps in the design process, Physical system, Modeling, Simulation, Evaluation, Optimal design, Computer aided design of thermal system. (5L)

MODULE-II

Modelling of thermal systems: Introduction, Types of models, Mathematical modelling, Modeling and similitude, Numerical modeling, System simulation, Flow of information, Synthesis of different design steps, Design of systems from different application areas(cooling of electronic equipments, heat transfer equipment). (5L)

MODULE-III

Problem formulation for optimization: Introduction, Objective function, Constraints, Optimization methods, Calculus methods, Search methods, Linear and dynamic programming, Geometric programming, Choice of variables for optimization, Sensitivity analysis, Multi-objective optimization. (5L)

MODULE-IV

Lagrange multipliers method, Significance of the multipliers, Optimization of unconstrained problems, Conversion of constrained to unconstrained problem, Optimization of constrained problems, Applicability to thermal systems. (5L)

Module-V

Search methods: Unconstrained search with multiple variables, Lattice search, Univariate search, Steepest ascent/descent method, Multivariable constrained optimization, Penalty function method, Search along a constraint, Examples of thermal system. (5L)

MODULE-VI

Geometric programming: Mathematical proof, Constrained optimization, Non zero degree of difficulty, Linear and dynamic programming. (5L)

MODULE-VII

Knowledge based design considerations: Introduction, Basic components, Expert knowledge, Design methodology, Application to thermal system. (5L)

Books:

1. Design and Optimization of Thermal System by Yogesh Jaluria
2. Design of Thermal System by Wilbert Stoecker.

MME 1011: THEORY AND DESIGN OF I.C. ENGINES

MODULE-I

Performance Parameters and Characteristics: Indicated and brake mean effective pressure, IP & BP, air standard, indicated and brake thermal, mechanical, relative, volumetric, scavenging, charge and combustion efficiencies, Performance characteristics and variables affecting the performance characteristics, Methods of improving Engine performance, Performance maps. (5L)

MODULE-II

Alternate Fuels: Solid, Liquid and gaseous fuels, Liquid fuels- Alcohol, methanol, ethanol, reformulated gasoline, water gasoline mixture, Gaseous fuels- Hydrogen, natural gas, CNG, LPG, their advantages and disadvantages, Biogas, dual fuel operation. (5L)

MODULE-III

Air Capacity of Four-Stroke Engines and Supercharging: Ideal air capacity, volumetric efficiency, effect of engine variables on volumetric efficiency, supercharging for S.I. and C.I. engines, types of superchargers and their characteristics, exhaust supercharging, performance of supercharged engines. (5L)

MODULE-IV

Electronic Fuel Injection systems: EFI system-merits and demerits, Multi-Point Fuel Injection (MPFI) system, Electronic Diesel Injection System, CRDI system. (5L)

MODULE-V

Engine Emissions and their control: Air pollution due to IC engines, Exhaust and non-exhaust emissions, HC,CO and NOx emissions and their causes, Photochemical smog, Particulates, Aldehyde, suplhur, lead, phosphorous emissions, Emission control methods. (5L)

MODULE-VI

Engine Design: General design: types of cycle, number of cylinder and arrangements, compression ratio, speed, stroke-bore ratio, displacement, combustion chamber shape. Design of Principal Parts: cylinder, cylinder head, Crank case, pistons connecting rod, crank shaft, valves inlet and exhaust manifolds. (5L)

MODULE-VII

Design of Cooling System: Engine cooling arrangements, basic heat transfer equation, estimation of heat loss, radiator and fin design. (5L)

Books:

1. Internal Combustion Engines by E.F. Obert
2. Internal Combustion Engines by C.F. Taylor and Taylor
3. Internal Combustion Engines by M.L. Maleev
4. Diesel Engine Design by H.F.P. Purdey.

MME 2001: ADVANCED THERMODYNAMICS

MODULE-I
Recapitulation of fundamentals: Basic definitions and concepts, laws of thermodynamics, entropy flow and entropy production, third law of Thermodynamics. (5L)

MODULE-II
Availability in steady flow open system and in a closed system; Exergy analysis of typical thermal systems, Irreversibility and effectiveness. (5L)

MODULE-III
Properties and Pure substance: P-V-T surface, phase diagrams, phase changes, various property diagrams. First order phase transition and Clapeyron's equation, second order phase transition and Ehrenfest's equations, Maxwell's equations: equations for internal energy, enthalpy, entropy, specific heat, and Joule-Thomson coefficient. (5L)

MODULE-IV
Equation of state for real gases: Compressibility factor and generalized compressibility chart, law of corresponding states, Pseudocritical pressure and temperature, reduced co-ordinates, Vander Wall's equation of state, and other equations of state. (5L)

MODULE-V
Basic concepts of Irreversible Thermodynamics: Onsagar theory, derivation of Onsagar equations, Onsagar Reciprocal Relations, Fluctuation theory, Regression of fluctuations. (5L)

MODULE-VI
Chemical Thermodynamics: Gibb's theorem, Gibb's function of mixture of inert ideal gases. Chemical equilibrium, Thermodynamics equation for phase, degree of Reaction, equation of reaction equilibrium, Law of Mass Action, Heat of Reaction and Vant hoff Isobar, Saha's equation for standard Gibb's function change, affinity. (5L)

MODULE-VII
Statistical Thermodynamics: Importance of statistical anlysis, Stirling's approximation, Bose-Einstein statistics and Fermi-Dirac statistics, classical Maxwell-Boltzman model, equilibrium distribution, microscopic interpretation of heat and work, entropy, second law of thermodynamics, partition function and its properties. (5L)

Books:

1. Concept of Thermodynamics by O.R. Obert
2. Heat and Thermodynamics by M. Zemansky
3. Thermodynamics by G.J. VanWylen
4. Thermodynamics by Holman.

MME-2013 REFRIGERATION AND AIR CONDITIONING

MODULE-I

Cooling and Heating Load Calculations - I: Estimation of Solar Radiation : Introduction to cooling and heating load calculations, Solar radiation, Solar geometry, Calculation of direct, diffuse and reflected radiation using ASHRAE solar radiation model, Effect of clouds. (5L)

MODULE-II

Cooling and Heating Load Calculations –II :Solar Radiation Through Fenestration Ventilation And Infiltration Need for fenestration in buildings and effects of fenestration on air conditioning systems, concepts of Solar Heat Gain Factor (SHGF) and Shading Coefficient, calculation of shaded area of fenestrations, Need for ventilation and recommended ventilation rates, Infiltration and causes for infiltration, Estimation of heat transfer rate due to infiltration and ventilation. (5L)

MODULE-III

Cooling and Heating Load Calculations - III:

Heat Transfer Through Buildings - Fabric Heat Gain/Loss General aspects of heat transfer through buildings, one-dimensional, steady state heat transfer through homogeneous, non-homogeneous walls, opaque walls and roofs with suitable initial and boundary conditions, semi-empirical methods based on Effective Temperature Difference or Cooling Load Temperature Difference, discuss the physical significance of decrement and time lag factors and present typical tables of CLTD for walls and roof. (5L)

MODULE-IV

Selection of Air Conditioning Systems: Introduction to thermal distribution systems and their functions, Selection criteria for air conditioning systems, Classification of air conditioning systems, Working principle, advantages, disadvantages and applications of all air systems, e.g. single duct, constant volume, and single/multiple zone system, single duct, dual duct, constant & variable air volume (VAV) systems, outdoor air control in all air systems, advantages/disadvantages & applications of all air systems, working principle, advantages, disadvantages and applications of all water systems, air-water systems, working principle, advantages, disadvantages and applications of unitary refrigerant based systems. (5L)

MODULE-V

Transmission of Air in Air Conditioning Ducts: Air Handling Unit (AHU) and its functions, need for transmission aspects of air in air conditioning, airflow through air conditioning ducts, Bernoulli and modified Bernoulli equations, Static, dynamic, datum and total head, Fan Total Pressure (FTP) and power input to fan, estimation of pressure loss through air conditioning ducts,, Estimation of frictional pressure drop of circular and rectangular ducts using friction charts and equations, Estimation of dynamic pressure drop in various types of fittings, Static regain. (5L)

MODULE-VI

Design of Air Conditioning Ducts: Important requirements of an air conditioning duct, General rules for duct design, Classification of duct systems, Commonly used duct design methods, Principle of velocity method, Principle of equal friction method, Principle of static regain method, Performance of duct systems, System balancing and optimization, Introduction to fans and fan laws, Interaction between fan and duct systems. (5L)

MODULE-VII

Ventilation for Cooling Use of ventilated air for cooling of buildings and cooling of occupants, comparison between natural ventilation and mechanical ventilation, characteristics of natural ventilation and estimation of airflow rate due to wind and stack effects, general guidelines for natural ventilation and forced ventilation using electric fans, interior air movement using interior fans, unit ventilators, whole house fans and solar chimneys. (5L)

Books:

1. Refrigeration and Air Conditioning by Stooker W. F.
2. Refrigeration and Air Conditioning by C. P. Arora, Tata McGraw-Hill
3. Refrigeration and Air Conditioning by Ahmadul Ameen, PHI Publication
4. Hand Book of Air conditioning and Refrigeration by Shan k. Wang, Tata McGraw-Hill

MME 2011: GAS TURBINE AND JET PROPULSION

MODULE- I

Gas turbine system and cycles: Principles of gas turbine systems, Ideal cycle analysis, Performance of practical gas turbine cycles, Effect of varying mas flow, Effect of variable specific heat, Mechanical losses, Loss due to incomplete combustion, Polytrophic efficiency. (5L)

MODULE-II

Centrifugal compressors: Principle of operation, Work-done and pressure rise, Diffuser, compressibility effects, Non-dimensional quantities for plotting compressor characteristics, Compressor characteristics. (5L)

MODULE-III

Axial flow compressors: Basic operation, Elementary theory, Factor effecting stage pressure ratio, Blockage in the compressor annulus, Degree of reaction, Three dimensional flow, Design process, Blade design, Calculation of stage performance, Compressibility effects, Axial compressor characteristics. (5L)

MODULE-IV

Axial and radial flow turbines: Elementary theory of axial flow turbine, Vortex theory, Choice of blade profile, Pitch and chord, Estimation of stage performance, Overall turbine performance, the cooled turbine, Radial flow turbine. (5L)

Module-V

Combustion systems: Operational requirement, Types of combustion system, Some important factors effecting combustor design, the combustion processes, Combustion chamber performance, Mixing and dilution, Combustion chamber arrangement. (5L)

MODULE-VI

Jet propulsion cycles and their analysis: Introduction, the Ramjet, Pulsejet, Turbojet, Turboprop, Thrust and thrust equations, Specific thrust of the turbojet engine, Efficiencies, Parameters effecting flight performance and thrust argumentation. (5L)

MODULE-VII

Rocket propulsion: Principle of rocket propulsion, Analysis of an ideal chemical rocket, Optimum expansion ratio for rocket, the chemical rocket, Advantages of liquid propellant rockets over solid propellant rockets, Free radial propulsion, Nuclear propulsion, Photon propulsion. (5L)

Books:

1. Gas turbine theory by Cohen and Rogers
2. Gas turbines by V. Ganesan

MME 2005: FUELS AND COMBUSTION

MODULE I
Conventional Solid, liquid and gaseous fuels, Manufacture and uses of Producer gas and water gas. (5L)

MODULE II
Substitute fuels and miscellaneous synthetic fuels. (5L)

MODULE III
Chemical equation of combustion and conservation of mass, Enthalpy of formation, Enthalpy and Internal Energy of Combustion, Adiabatic Flame Temperature. Equilibrium and dissociation, reversible chemical reaction and equilibrium constant. (5L)

MODULE IV
Chemical Kinetics: rate and order of reaction, First and Second order reactions. (5L)

MODULE V
Molecular Kinetics: Molecular and order, Theories of Collision. (5L)

MODULE VI
Flames and Combustion, flame propagation, Quenching and Ignition, Flammability – Theories of flame propagation.Diffusion Flame: Combustion of solid, Liquid particles packed beds and gaseous jets. (5L)

MODULE VII
Flame Stabilization: Unstable flames, Solid carbon in flames.Atomization, vapourization and mixing, Engineering implications of combustion studies: Design methods. (5L)

Books:

1. Chemical Kinetic – M. L. Smith and K. W. Steenson
2. Chemistry – M.J. Sienko and M.J. Plane
3. Flame and Combustion – J.N. Radley
4. Alternative Energy Sources – Nejat Veziroglu