

Master of Technology
In
Mechanical Engineering (Thermal)

Course Structure & Syllabus



Department of Mechanical Engineering
National Institute of Technology Hamirpur
Hamirpur (HP) – 177005, India

Course Structure of M.Tech. Mechanical Engineering (Thermal)

SEMESTER-I

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ Week	Credit
			L	T	P		
1	ME-611	Advanced Thermodynamics	4	0	0	4	4
2	ME-612	Gas Dynamics	4	0	0	4	4
3	ME-613	Conductive and Radiative Heat Transfer	4	0	0	4	4
4	ME-7MN	Programme Elective I	4	0	0	4	4
5	ME-7MN	Programme Elective II	4	0	0	4	4
6	ME-614	Thermal Engineering Lab-I	0	0	4	4	2
Total			20	0	4	24	22

Programme Elective-I & II: List of Programme Electives is given in the Annexure.

SEMESTER-II

Sr. No.	Course No.	Course Name	Teaching Schedule			Hours/ Week	Credit
			L	T	P		
1	ME-621	Computational Fluid Dynamics and Heat Transfer	4	0	0	4	4
2	ME-622	Design of Thermal Systems	4	0	0	4	4
3	ME-623	Convective Heat Transfer	4	0	0	4	4
4	ME-7MN	Programme Elective III	4	0	0	4	4
5	ME-7MN	Programme Elective IV	4	0	0	4	4
6	ME-624	Thermal Engineering Lab-II	0	0	4	4	2
Total			20	0	4	24	22

Programme Elective-III & IV: List of Programme Electives is given in the Annexure.

SEMESTER-III

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME- 800	M.Tech. Dissertation	--	20
Total			--	20

SEMESTER-IV

Sr. No.	Course No.	Course Name	Hours/Week	Credit
1	ME- 800	M.Tech. Dissertation	--	20
Total			--	20

Total Credit of the Programme=84

Annexure

List of Programme Electives

Programme Elective-I

ME-731 Computational Methods in Thermal Engineering
ME-732 Experimental Methods in Thermal Engineering
ME-733 Optimization Methods in Thermal Engineering

Programme Elective-II

ME- 734 Alternative Fuels Technology
ME- 735 Engine Tribology
ME- 736 Internal Combustion Engines and Pollution

Programme Elective-III

ME- 741 Gas Turbine and Jet Propulsion
ME- 742 Design of Thermal Turbo Machines
ME- 743 Design of Air Conditioning System

Programme Elective-IV

ME- 744 Exergy Analysis of Thermal Systems
ME- 745 Design and Analysis of Solar Energy Systems
ME- 746 Design of Pumps and Turbines

Course Name: Advanced Thermodynamics	
Course Code: ME-611	
Course Type: Core	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart knowledge about the concept of basic thermodynamic systems. • To impart knowledge of real gas behaviour and introduction to exergy and statistical thermodynamics. • To impart knowledge on different thermodynamic property relations and their applications. 	
Course Content	
<p>Review of Laws: Basic definitions and concepts, Basic laws of thermodynamics, Entropy flow and Entropy production, 3rd law of thermodynamics, Availability in steady flow open system and in a closed system, Energy analysis of typical Irreversibility.</p> <p>Equation of State for Real Gases: Compressibility factor and generalized compressibility chart, Law of corresponding state, Law of pseudo critical pressure and temperature, Reduced coordinate, Vander- Waals equation of state and other equation of state.</p> <p>Thermodynamic Property Relation: Residual property function, Property of saturation state, Thermodynamic properties of homogeneous mixture</p> <p>Exergy Analysis: Concept of exergy, Energy analysis for open and closed systems with fixed and moving boundaries, Dead state and irreversibility, Exergy loss due to mixing of fluids, Second law efficiency, Exergy analysis for power and refrigerating cycles.</p> <p>Reacting Systems and Chemical Equilibrium: Chemical systems, Enthalpy of reaction, Combustion and formation, 1st and 2nd law analysis of reacting systems, Adiabatic flame temperature, Fuel cells types and applications, Criteria for chemical equilibrium, Chemical potential fugacity and fugacity coefficient, Henry and Raoult's law, Gibbs phase rule, Hess's law.</p> <p>Real Gases: Assumptions of real gases, Equations of state for real gases, Compressibility factor, Compressibility chart, Reduced pressure and temperature, Pressure and energy equations using kinetic theory, RMS velocity, Equi-partition of energy, Mean free path, Maxwell distribution function.</p>	
Course Outcomes	
<p>Upon successful completion of course, the students will be able to</p> <p>CO1: Apply the concepts of entropy and exergy analysis for analyzing industrial and domestic applications.</p> <p>CO2: Estimate the properties of pure substance and thermodynamic properties of real gases.</p> <p>CO3: Apply energy balances to reacting systems for both closed and open systems.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Advanced Engineering Thermodynamics by A. Bejan, John Wiley and Sons. 2. Advanced Thermodynamics for Engineers by K. Wark, McGraw Hill. 3. Fundamentals of Thermodynamics by R.E. Sonntag, C. Borgnakke and G.J. Van Wylen, Wiley. 4. Principles of engineering thermodynamics by M.J. Moran, H.N. Shapiro, Wiley. 	

Course Name: Gas Dynamics	
Course Code: ME-612	
Course Type: Core	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To understand various theoretical concepts related to compressible flow, normal and oblique shock waves, variable area flow, flow with heat addition. • To understand the working of various systems related to gas dynamics: shock waves, adiabatic flow in a duct. • To understand and apply mathematical treatment to various problems related to generalized quasi-one-dimensional flow. 	
Course Content	
<p>Fundamentals of Compressible Flow: Continuity, Momentum and energy equation, Control volume, Sonic velocity, Mach number and its significance, Mach waves, Mach cone and Mach angle, Von Karman rules of supersonic flow, Static and stagnation states, Relationship between stagnation temperature, Pressure, Density and enthalpy in terms of Mach number, Stagnation velocity of sound, Reference speeds, Various regions of flow, Effect of Mach number on compressibility.</p> <p>Isentropic Flow with Variable Area: One dimensional isentropic flow in ducts of varying cross-section-nozzles and diffusers, Mass flow rate in nozzles, Critical properties and choking, Area ratio as function of Mach number, Impulse function, Effect of back pressure variation of convergent and convergent divergent nozzles, Non-dimensional mass flow rate in terms of pressure ratio, Area ratio and Mach number, Flow through diffusers, operation and analysis of C-D- nozzles, Use of gas tables.</p> <p>Flow in Constant Area Duct with Friction (Fanno flow): Fanno curve and Fanno flow equations, Solution of Fanno flow equations, Variation of flow properties, Variation of Mach no. with duct length, Frictional choking, Isothermal flow in constant area duct with friction, Tables and charts for Fanno flow.</p> <p>Flow in Constant Area Duct with Heat Transfer (Rayleigh flow): Rayleigh curve and Rayleigh flow equations, Variations of flow properties, Maximum heat transfer, Thermal Choking, Tables and charts for Rayleigh flow.</p> <p>Normal and Oblique Shock Waves: Development of shock wave, Governing equations, Prandtl-Mayer relation, Rankine-Hugoniot relation, Strength of shock wave, Mach number in the downstream of normal shock, Variation of flow parameters across the normal shock, Normal shock in Fanno and Rayleigh flows, Compression shock wave and expansion fan, Analysis of oblique shock wave.</p> <p>Introduction to Experimental Facilities: Types of wind tunnels-Sub sonic wind tunnel, Supersonic wind tunnel, Free-piston shock tunnel, Detonation-driven shock tunnels, and Expansion tubes.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Solve flow equations for quasi one-dimensional flow through variable area ducts.</p> <p>CO2: Analyze flow through constant area ducts with friction and heat transfer.</p> <p>CO3: Analyze flows with normal and oblique shocks.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Dynamics of Compressible Flow by S.M. Yahya, New Age Publishers. 2. Fundamentals of Compressible Fluid Dynamics by P. Balachandran, PHI Learning. 3. Fundamental of Gas Dynamics by V. Babu, CRC Press. 4. Gas Dynamics by E. Rathakrishanan, PHI Learning. 	

Course Name: Conductive and Radiative Heat Transfer	
Course Code: ME-613	
Course Type: Core	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart knowledge of 2D and 3D conduction heat transfer. • To understand radiative heat transfer with & without participating media. • To formulate and analyze combined heat transfer problems. 	
Course Content	
<p>Steady and Transient Conduction: Analysis and design of variable cross section circumferential fins, Lumped parameter and semi-infinite solid approximations, Analysis of 2D and 3D heat conduction in solids with complex boundary conditions and heat generation, Transient conduction in simple systems as well as its analysis with complex boundary, Concept of isotropic homogeneous conductivity, Orthotropic and anisotropic solids, Application of Duhamel's theorem, Use of Laplace transformation in linear conduction problems, Use of Green's 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.</p> <p>Radiative Heat Transfer: Review of Basic laws- Stefan Boltzmann's law, Kirchhoff's law, Wien's law, Plank's law etc. Black body, Gray body, Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation, Radiation transfer between surfaces, Radiation through semi-transparent materials, Techniques to estimate configuration factors, Radiative heat exchange between gray and diffuse surfaces, Partially specular gray surfaces and non-ideal surfaces, Radiative Heat transfer with participating media, Radiative combined with conduction and convection, Method of discrete ordinates, Zonal method and Monte Carlo method for thermal radiation.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Carry out conductive and radiative heat transfer analysis.</p> <p>CO2: Analyze problems involving steady state & transient heat conduction in simple as well as complex geometries.</p> <p>CO3. Able to analyze combined heat transfer problems with and without participating media.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Analytical Methods in Conduction Heat Transfer by G. Meyers, Amch Publishers. 2. Heat Conduction by N. Ozisik, John Wiley and Sons publication. 3. Thermal Radiation Heat Transfer by R. Siegel and J. Howell, CRC Press. 4. Radiative Heat Transfer by M. F. Modest, Academic Press. 	

Course Name: **Computational Fluid Dynamics and Heat Transfer**

Course Code: **ME-621**

Course Type: **Core**

Contact Hours/Week: **4L**

Course Credits: **04**

Course Objectives

- To impart knowledge about concepts of Finite Volume Method (FVM).
- To impart knowledge about the application of FVM for different fluid flow & heat transfer problems.
- To impart knowledge about grid generation.

Course Content

Introduction to CFD: Role of CFD and its application, Future of CFD, Governing equations (GE's) of fluid dynamics, Modeling of flow, Control volume concept, Substantial derivative, Physical meaning of the divergence of velocity, Continuity equation, Momentum equation, Energy equation and its conservation form, Equation for viscous flow (Navier-Stokes equation), Equation for inviscid flow (Euler equation), Different forms of GE's, Initial and boundary condition.

FVM for Diffusion Problems: FVM for 1D steady state diffusion, 2D steady state diffusion, 3D steady state diffusion, Solution of discretized equation-TDMA scheme for 2D and 3D flows.

FVM for Convection-Diffusion Problems: FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power law scheme, QUICK scheme.

FVM for Unsteady Flows: 1D unsteady heat equation (Explicit, Crank-Nicolson, Fully implicit schemes), Implicit methods for 2D and 3D problems, Discretization of transient convection-diffusion problems, Solution procedure for transient unsteady flow calculations (Transient SIMPLE, Transient PISO algorithms).

Solution Algorithm for Pressure-Velocity Coupling in Steady Flows: Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.

Grid Generation: General transformation of the equation, Metrics and Jacobians, Types of grids-structure and unstructured grids, Grid generation methods-algebraic, Differential and hybrid methods, Coordinate stretching, Boundary-fitted coordinate systems, Elliptic and hyperbolic grid generation methods, Orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation, Latest development in CFD techniques and newer applications.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand flow physics and mathematical model of governing Navier-Stokes equations and define proper boundary conditions for solution.

CO2: Use CFD software to solve relevant engineering flow problems.

CO3: Analyse the CFD results. Compare with available data, and discuss the findings.

Books and References

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H.K. Versteeg and W. Malalasekara, Pearson Education.
2. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing.
3. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill.
4. Computational Techniques for Fluid Dynamics Volume I & II by C.A.J. Fletcher, Springer.

Course Name: Design of Thermal Systems	
Course Code: ME-622	
Course Type: Core	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart the knowledge about the concept of design of thermal systems. • To provide an introduction to computer-aided design of thermal systems, including cost and performance analysis. • To learn tools and techniques of analysis of a thermal systems. 	
Course Content	
<p>Introduction to Thermal System Design: Engineering design, Designing a workable system, Conceptual design, Steps in the design process, Computer-aided design of thermal systems, Types of thermal system models, Interaction between models, Mathematical modelling, Physical modelling and dimensional analysis, Curve fitting techniques, Design of a food freezing plant.</p> <p>Numerical Modeling and Simulation: Solution procedure, Numerical model for a system, System simulation, classes of simulation, Methods for numerical simulation, Successive Substitution, Modeling thermal equipment, Selecting vs simulating a heat exchanger, Workable and optimum systems, Optimization procedures, Lagrange multipliers, Geometric programming, Setting up mathematical statement of optimization problem, Case study on water chilling system.</p> <p>Dynamic Behaviour of Thermal Systems: Dynamic analysis, One dynamic element in a steady state simulation, Laplace transform, Inversion of Laplace transform, Solution of ordinary differential equation, Study of modern developments in thermal systems along with their design, Operation and economic aspects.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Understand the aspects of designing of thermal systems.</p> <p>CO2: Solve the problem using numerical simulation by choosing the design variables which affects the problem.</p> <p>CO3: Explain economic aspects of designing and able to apply different techniques of optimization applicable to thermal system.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Design and Optimization of Thermal systems by Yogesh Jaluria, CRC Press. 2. Design of thermal systems by W.F. Stocker, McGraw-Hill Education. 3. Principles of Solar Engineering by Goswami, Kreith and Kreider, Taylor and Francis. 4. Essentials of Thermal Systems Design and Optimization by C. Balaji, Ane Books Pvt. Ltd. 	

Course Name: Convective Heat Transfer	
Course Code: ME-623	
Course Type: Core	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart an introductory treatment of the governing laws for Convection heat transfer. • To formulate & reduce mass, momentum and energy conservation equations according to the physical situation involved. • To obtain exact and approximate solutions of external and internal boundary layer flow problems. 	
Course Content	
<p>Principles of Convection: Convection boundary layers, Velocity boundary layers, Thermal boundary layers, Significance of boundary layers, Laminar and turbulent flow, Significance of dimensionless parameters, Reynolds-Colburn analogy, Drag & amp, Heat transfer.</p> <p>Convective Heat Transfer in External Flows: Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl Number approximations, Optimal cooling of stack of vertical heat-generating plates.</p> <p>Convective Heat Transfer in Internal Flows: Concept of developing and fully developed flows, Thermally developing flows: Graetz problem, Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions, Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow and Couette flow and analytical evaluation of Nusselt numbers in limiting cases, Optimal cooling of stack of heat-generating plates, Heat lines in fully developed duct flow, Optimal duct shape for minimum flow resistance, Enclosures heated from below, Heat transfer results, Scale theory of the turbulent regime.</p> <p>Free Convection: Free convection boundary layer equations: order of magnitude analysis, Similarity and series solutions, Concept of thermal stability and Rayleigh Bernard convection. Combined natural and forced convection (Mixed Convection), Heat transfer results including the effect of turbulence, Vertical walls, Inclined walls, Horizontal cylinder, Sphere, Distribution of heat sources on a vertical wall.</p> <p>Convection with Change of Phase: Condensation, Boiling, Contact melting and lubrication, Melting by natural convection, Quasi-steady convection regime, Horizontal spreading of the melt layer.</p> <p>Convection in Porous Media: Mass conservation, Darcy flow model and the Forchheimer modification, Enclosed porous media heated from the side, Penetrative convection, Lateral penetration, Vertical penetration.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Analyze boundary layer development problems.</p> <p>CO2: Analyze external and internal forced convection by applying existing empirical correlations.</p> <p>CO3: Examine the convective heat transfer in porous media and in systems involving phase change.</p> <p>CO4: Apply the concepts to analyze industrial problems.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Convective Heat Transfer by Louis C. Burmeister, John Wiley and Sons. 2. Convective Heat Transfer by Bejan, Wiley Publication. 3. Convective Heat Transfer by S. Kakac, Y. Yener & A. Pramuanjaroenkij, CRC Press. 4. Heat Transfer by Kays & Crawford, McGraw-Hill Companies. 	

Course Name: Computational Methods in Thermal Engineering	
Course Code: ME-731	
Course Type: Programme Elective-I	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> To impart knowledge of various computational methods dealing problems related to thermal engineering. To knowhow finite difference, finite element & boundary elements based computational methods. 	
Course Content	
Introduction to Computational Methods: Finite difference method (FDM), Finite element method (FEM), Boundary element method (BEM).	
Finite Difference Method (FDM): Introduction, History, Application, Discretization methods: Methods for solving discretized equations, Consistency, Stability and convergence, Representation of a derivative, Backward difference, Central difference, Forward, Backward and central difference, Stencil, Stencil in Y direction, 2 nd order and mixed derivative, Boundary consideration, Polynomial approach, Order of approximation, Application of FDM to thermal engineering problem-1D steady state conduction, Treatment of boundary condition, Algebraic equation and matrix form, Unsteady heat conduction with FDM, Application to transient heat transfer by FDM. Use of FDM for finding solution of 2D and 3D heat transfer problems-Steady state heat conduction, Flux boundary condition, Convective boundary condition and insulated boundary, Related problems.	
Finite Element Method (FEM): Introduction, History, Applications, Merits and demerits of FEM, Variational and weighted residual approaches of FEM, Finite elements and interpolation functions (1D, 2D, and 3D), Finite element formulation (Variational and Galerkin's) of 1D, 2D and 3D heat transfer problems, FE formulation of 1D heat transfer with mass transport using Galerkin's method.	
Boundary Element Method (BEM): Introduction, History, Applications, Merits and demerits of BEM, Approach of BEM, Numerical implementation-determination of C_i , Tackling kernel singularity; 3D BEM formulation for transient heat transfer problem.	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Use various programming languages to model & obtain solutions of relevant engineering problems.	
CO2: Analyse the outcomes and compare with available literature results in order to conclude the findings.	
Books and References	
<ol style="list-style-type: none"> Computational Fluid Mechanics and Heat transfer by D.A. Anderson, J.C. Tannehill, and R.H. Pletcher, Hemisphere Publishing Corporation. The Finite Element in Engineering by S.S. Rao, Butterworth Heinemann, Boston. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing. Computation Fluid Dynamics by Anderson Jr., McGraw Hill. 	

Course Name: Experimental Methods in Thermal Engineering	
Course Code: ME-732	
Course Type: Programme Elective-I	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To introduce the basics of experimentation involving the design of experiment & measurement systems. • To execute experimental data analysis as well as error/uncertainty analysis. 	
Course Content	
<p>Basic Concepts: Definition of terms, Calibration, System response, Importance of experimental analysis & planning.</p> <p>Measuring Systems: Selection of measuring system, Static & dynamic characteristics, Response of general form of instrument, Random and transient input, Instrument loading under static and dynamic condition, Transducer and sensor, Measurement of pressure, Temperature, Flow, Measurement of emissivity, Viscosity, Flow visualization methods, Shadow graph, Schlieren, Interferometer, Laser Doppler Anemometer.</p> <p>Analysis of Experimental Data: Causes and type of experimental errors, Uncertainty analysis, Statistical analysis of experimental data, Statistical distributions, Estimators, Confidence levels, Sample size, Test of hypothesis, Goodness-of-fit test, Chauvenet's criteria, Regression analysis, Co-relations.</p> <p>Design of Experiment: Inferences about means and standard deviations and considerations of different hypothesis, Factorial design, 2k and 3k factorial design, Blocking and confounding techniques in 2k factorial design, Concept of fractioning of factorial design, Response surface method, Introduction to robust design, robust parameter design for single response system, Experiments with non-normal data, Problems related to thermal engineering.</p> <p>Statistics: Hypothesis Testing rationale, Introduction to Factorial Experiments and DOE Terminology, Yate's algorithm for calculation of effects in a 2k design, Testing significance of effects in a 2k factorial experiment, Developing a mathematical model, Residual Analysis, Testing for model adequacy, Finding the structure of a Fractional factorial, Strategy, Principle and application of DOE.</p>	
Course Outcome	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Gain confidence in executing experimental investigations & data analysis.</p> <p>CO2: Understand & utilize the curve fitting techniques.</p> <p>CO3: Apply the principles of statistics.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Experimental methods for Engineers by Holman, McGraw Hill. 2. Experiments by Wu and Hamada, John Wiley. 3. Mechanical measurements, Beckwith, Marangoni and Lienhard, Pearson Publications. 4. Design and Analysis of Experiments by Douglas C. Montgomery, Wiley. 	

Course Name: Optimization Methods in Thermal Engineering	
Course Code: ME-733	
Course Type: Programme Elective-I	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To introduce students about the methods of optimization. • To impart knowledge of numerous methods used to solve the problems of thermal engineering. 	
Course Content	
<p>Introduction: Basic terminologies, Design variables, Objective function, Constraints and problem formulation etc. Linear programming, Simplex method, Duality in linear programming.</p> <p>Single Variable Unconstrained Optimization: Global optimum point, Local optimum point, Stationary point, Optimality criteria, Graphical method for optimum point, Direct methods for bracketing the optimum point: Exhaustive search method and bounding phase method, Refining the bracketed optimum point through region elimination methods: Interval halving method, Fibonacci search method and Golden section search method, Gradient based methods: Bisection method, Newton-Raphson method and Secant method.</p> <p>Multi-Variable Optimization Algorithm: Optimality criteria, Unidirectional search, Direct search methods, Box method, Hooke-Jeeves pattern search method, Powell's conjugate direction method, Gradient based methods: Cauchy's steepest descent method, Newton's method, Marquardt's method, Conjugate gradient method and variable metric method.</p> <p>Constrained Optimization Algorithms: Kuhn-Tucker conditions, Sensitivity analysis, Transformation methods, Penalty function method, Methods of multipliers (MOM).</p> <p>Specialized Algorithms: Integer Programming: Penalty function method, Branch and bound method, Geometric programming, Non-traditional optimization algorithms: Genetic algorithms, Simulated annealing, Tabu search, Ant colony optimization, Particle swarm optimization, Application of optimization methods in thermal engineering.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Understand & Execute the basic theoretical principles of optimization.</p> <p>CO2: Formulate various optimization models in order to yield solutions.</p> <p>CO3: Solve wide range of engineering problems related to thermal engineering.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Optimization for Engineering Design: Algorithms and Examples by Kalyanmoy Deb, Prentice Hall of India Pvt. Ltd. 2. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley India Pvt. Ltd. 3. Engineering Optimization: Methods and Applications by A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Second Edition, John Wiley & Sons, Inc. 4. Engineering optimization: theory and practice by Singiresu S Rao, Fourth Edition, New Age International Pvt. Limited Publishers. 	

Course Name: Alternative Fuels Technology	
Course Code: ME- 734	
Course Type: Programme Elective-II	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart knowledge about the importance of alternate fuels. • To introduce the fundamental concepts relevant to Hydrogen & Fuel cells 	
Course Content	
<p>Introduction: Estimate of petroleum reserve, Need for alternate fuel, Availability and comparative properties of alternate fuels, CNG, LPG, Alcohol, Vegetable oil and Bio-gas.</p> <p>CNG AND LPG: Availability, Properties, Modifications required in SI and CI engines, Performance and emission characteristics, Storage, Handling and dispensing, Safety aspects, Alcohol, Manufacture of alcohol, properties, Blending of methanol and ethanol, Engine design modifications required and effects of design parameters, Performance and emission characteristics, Durability, Types of vegetable oils for engine application, Extraction process, Biogas, Properties, Engine performance and emission characteristics.</p> <p>Hydrogen and Fuel Cells: Production methods, Properties, Performance and emission characteristics, Storage and handling, Safety aspects, Working principle, Classification, Description of fuel cell systems, Fuel cell components, Properties of fuel cell, General performance characteristics, Emission characteristics, Merits and demerits, Vehicle design and layout aspects.</p> <p>Emissions from SI & CI Engines and its Control: Emission formation in S.I. engines, Hydrocarbons, Carbon monoxide, Nitric oxide, Lead particulates, Polynuclear aromatic hydro carbon emission, Effects of design and operating variables on emission formation in spark ignition engines, Controlling of pollutant formation in engines, Thermal reactors, Catalytic converters, Charcoal canister control for evaporative emission, Positive crank case ventilation system for UBHC emission reduction, Chemical delay, Intermediate compound formation, Pollutant formation on incomplete combustion, Effect of operating variables on pollutant formation, Controlling of emissions, Driving behavior, Fumigation, Exhaust gas recirculation, Air injection, Cetane number effect.</p> <p>Emission Measurement and Test Procedure: Measurement of exhaust gases by NDIR, Dilution tunnel technique for particulate measurement, Procedures on engine and chassis constant volume sampling procedures.</p>	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Identify the fuel thermochemistry and fuel quality effects on emissions.	
CO2: Describe the modifications required and the effects of design parameters.	
Books and References	
<ol style="list-style-type: none"> 1. Internal Combustion Engines by Ganesan.V, Tata McGraw Hill. 2. Automotive Emission Control by Crouse. W.M, Anglin. A.L, McGraw Hill. 3. Engine Emissions & pollutant formation by G.S, Patterson. D.J, Plenum Press. 4. Alternative Fuel: Emission, Economic and Performance by Maxwell et al, SAE. 	

Course Name: Engine Tribology Course Code: ME- 735 Course Type: Programme Elective-II	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives <ul style="list-style-type: none"> • To impart knowledge about the surfaces and their related terminologies. • To introduce the fundamental concepts of friction and wear of engine parts • To know the types of lubrication • To enable the students to understand the factors that causes the wear and friction. 	
Course Content	
<p>Introduction: Fundamentals of tribology, General tribological considerations in the engine components such as bearings, gears, cams, followers, reciprocating parts and dynamometer.</p> <p>Surface Properties: Surface topography and its measurement, Quantifying surface roughness, Statistical methods of surface texture assessment, Surface modifications and surface coatings, Measurement of surface roughness.</p> <p>Friction: Theories of friction, Sliding friction, Rolling friction characteristics of common metals and non-metals friction under different environments, Engine friction-Losses and engine design parameters, Friction in extreme conditions.</p> <p>Wear: Types of wear and their mechanism, Mechanism of sliding wear of metal, Fretting wear of metals, Factors affecting wear, Selection of materials for different wear situations, Measurement of wear, Engines wear mechanisms, Wear resistant materials and coatings and failure mode analysis.</p> <p>Lubrication: Basic concepts of lubrication, Lubrication regimes in IC Engine, Generalized Reynolds equation, Types of fluid film bearings, Hydrodynamic journals bearings, Short and finite bearings, Thrust bearings, Sintered bearing, Non-circular bearings, Multi-recess journal and thrust bearings, Air and gas lubricated bearings, Engine lubrication and bearings, Lubrication of cam-follower, Valve train mechanism, Type of lubrication for various parts of engine.</p> <p>Lubricants: Type of lubricants, Classification of lubricants, Gear oil and engine oil properties and testing, Service schedule, Lubrication system, Lubricant monitoring and testing, Ferrography and other rapid testing methods for lubricants contamination.</p>	
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand about different concepts related to friction, Wear and Lubrication. CO2: Know about the various types of wear and their identification and estimation. CO3: Understand the need and requirement of Lubrication and mechanisms.	
Books and References <ol style="list-style-type: none"> 1. Applied Tribology - Bearing Design and Lubrication by Michael M Khonsari, Wiley. 2. Engineering Tribology by John William, Cambridge University Press. 3. Introduction to Tribology by Bharat Bhushan, Wiley India. 4. Engine Tribology by C M Taylor, Elsevier. 	

Course Name: Internal Combustion Engines and Pollution	
Course Code: ME-736	
Course Type: Programme Elective-II	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To impart knowledge about the S.I & C.I engines • To introduce the fundamental concepts relevant to pollutant emissions. • To enable the students to understand the factors that cause the effects of emissions. 	
Course Content	
<p>Introduction: IC engines and components of IC engine, Comparison of two stroke & four stroke engines, Comparison between SI & CI engines, Valve and port timing diagram, Working cycles-otto, Diesel and dual cycle, Problem solving, Testing and performance, Measurement of brake power, Measurement of friction power, Requirement of cooling of the engine, Types of cooling.</p> <p>Fuel: Fuel- structure & composition of IC engine fuel, Properties of SI and CI engine fuel, Fuel rating, Fuel additives and non-petroleum fuels (alternative fuels). Fuel air requirement for ideal normal operation, Maximum power & quick acceleration, Simple carburetor and its parts, Problem solving.</p> <p>Fuel Injection System and Ignition: Petrol injection, Lucas petrol injection system, Electronic petrol injection system, Requirements & type of diesel injection system, Fuel pump, Types of injectors, Ignition system- requirements of ignition system, Battery and magneto ignition system, Ignition timing, Spark plug, Spark advance mechanism, Comparison between conventional ignition system, Electronic ignition system, Factors affecting energy requirement of ignition system.</p> <p>Combustion: Stages of SI engine combustion, Effect of engine variables on ignition lag flame front propagation, Abnormal combustion, Pre-ignition & detonation, Theory of detonation, Effect of engine variables on detonation, Stages of CI engine combustion, Effect of engine variables on delay periods, Stages of CI engine combustion, Effect of engine variables on delay periods.</p> <p>Pollutant Emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI engines, Generation and controlling the formation of NO_x, HC, CO, CO₂, Smoke, Measurement of engine emissions-instrumentation, Pollution control strategies, Emission norms-EURO and Bharat stage norms, Effect of emissions on environment and human beings.</p> <p>Control Techniques for Reduction of Emission: Design modifications, Optimization of operating factors, Fuel modification, Evaporative emission control, Exhaust gas recirculation, SCR-Fumigation, Secondary air injection, PCV system, Particulate trap, Exhaust treatment in SI engines, Thermal reactors, Catalytic converters, Catalysts, Use of unleaded petrol.</p> <p>Recent Trends: Air assisted combustion, Homogeneous charge compression ignition engines, Variable geometry turbochargers, Common rail direct injection systems, Hybrid electric vehicles, NO_x absorbers, Onboard diagnostics.</p>	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Understand the underlying principles of operation of different I.C engines and components.	
CO2: Provide knowledge on pollutant formation, control, recent trends etc.	
Books and References	
<ol style="list-style-type: none"> 1. Internal Combustion Engine Fundamentals by J.B. Heywood, McGraw-Hill. 2. Internal Combustion Engines by Ganesan, V, Tata McGraw Hill Book Co. 3. Fundamental of Internal Combustion Engine by Z. Smith, Gill, Oxford & IBH Publishing Co. Pvt. Ltd. 4. Engineering Fundamentals of the Internal Combustion Engines by Willard W. Pulkrabek, Second Edition, Pearson Prentice Hall. 	

Course Name: **Gas Turbine & Jet Propulsion**

Course Code: **ME-741**

Course Type: **Programme Elective-III**

Contact Hours/Week: **4L**

Course Credits: **04**

Course Objectives

- To understand the compressible fluid flow in turbines and compressors.
- To understand the thermodynamic cycles of jet engines.
- To understand the combustion physics in combustion chambers.

Course Content

Gas Turbine Systems:

Introduction: Relative merits over conventional IC Engines, Introduction to Brayton and Atkinson cycle for Gas turbines, Pressure Ratio, Thermal Efficiency, Specific Output, Optimum pressure ratio, Enhancement of thermal efficiency and/or specific power output using inter cooling, Heat exchangers, Reheat burners.

Compressors: Centrifugal compressor-major components: Inducer, Impeller, Vaneless diffuser, Vaned diffuser, Volute casing, Velocity & pressure variation in a stage, Pressure rise for radial tipped vanes, Degree of Reaction, Prewhirl and surging, Axial flow compressor: Stage consisting of a rotor and a stator, Pressure rise in a stage, Polytropic efficiency, Losses in a compressor stage, Phenomenon of blade stall & surging and performance curve axial flow turbine, Stage consisting of a rotor and a stator, Pressure rise in a stage, Polytropic efficiency, Losses in a compressor stage, Phenomenon of choking, Performance curves.

Jet Propulsion Systems:

Introduction: Concept of propulsion and thrust, Variety of propulsion systems for flying vehicles – Turbo-prop, Turbojet, Ram Jet, Pulse Jet, Scramjets with supersonic combustion, Definition & derivation for pressure thrust, Momentum thrust, Propulsive power, Propulsive efficiency, Thermal and overall efficiency, Thrust augmentation: Water injection, Liquid injection, Afterburning, Bleed air system, Rocket propulsion: Distinction between turbojets and rockets, Rocket thrust, Specific impulse, Total impulse, Thermal efficiency, Rocket equation and applications.

Combustion Systems: Concept of flame, Adiabatic flame temperature, Combustion mechanism in a combustor, Activation energy, Arrhenius law, Stoichiometry, Flame propagation, Flame stability, Pressure losses, Combustion intensity, Combustion efficiency, Combustion chamber requirements, Outlet temperature distribution, Gas turbine fuels, Pollution problems, Blade cooling methods, Requirements of the combustion chamber.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Evaluate the performance characteristics of Gas Turbines under different operating conditions.

CO2: Interpret the basic principle of Jet Propulsion –for air-breathing Aircraft Engines and their performances.

CO3: Perform and report preliminary design calculations to size jet engines to meet specific performance goals.

Books and References

1. Gas Turbines by V. Ganesan, Tata McGraw-Hill Education.
2. Gas Turbine Theory by H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, Paul Straznicky, Pearson education Ltd.
3. Fundamental of Propulsion by V. Babu, ANE Books.
4. Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion by S. M. Yahya, New Age Publishers.

Course Name: Design of Thermal Turbo machines	
Course Code: ME- 742	
Course Type: Programme Elective-III	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To introduce fundamental concepts related to design of compressor and turbines. • To enable the students to understand the performance of various types of gas turbines. 	
Course Content	
<p>Centrifugal Compressors: Principle of operation, Work done and pressure rise, Components of centrifugal compressor, Stage pressure, Stage efficiency, Degree of reaction, Dimensionless parameters, Slip factor, Causes of slip, Velocity triangles, Euler work, Design of impeller, Design of diffuser, Design of vane less diffuser, Design of volute casing.</p> <p>Axial Flow Compressors: Basic operation, Elementary theory, Factors affecting stage pressure ratio, Blockage in the compressor annulus, Degree of reaction, Three dimensional flow, Design process, Blade design, Calculation of stage performance, Compressibility affects, Off-design performance, Axial compressor characteristic.</p> <p>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, Radial flow turbine.</p> <p>Performance Prediction of Gas turbines: Component characteristics, Off-design operation of the single shaft turbine, Equilibrium running of gas generator, Off-design operation of free turbine engine, Off-design operation of the jet engine, Methods of displacing the equilibrium running line, Incorporation of variable pressure losses.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Design compressors and turbines.</p> <p>CO2: Establish performance characteristics curves of thermal turbomachines.</p> <p>CO3: Assess & analyze the performance outcomes of thermal turbomachines.</p>	
Books and References	
<ol style="list-style-type: none"> 1. Centrifugal compressors: A basic guide by M.P. Boyce, Penn Well Books. 2. Gas Turbine theory by Cohen, Rogers, Tata McGraw-Hill. 3. Axial Flow Compressors: A strategy for aerodynamic design and Analysis by R. Aungier, ASME Press. 4. Turbine Compressors and Fans by S.M. Yahya, Tata McGraw-Hill. 	

Course Name: Design of Air Conditioning System	
Course Code: ME-743	
Course Type: Programme Elective-III	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • To understand the design basics of air conditioning systems. • To estimate the capacity requirement of an air conditioning system for particular applications. • To design air conditioning system for specific need. 	
Course Content	
<p>Psychometric Processes & Design Condition: Review of psychometric properties, Review of psychometric processes, Choice of inside and outside design conditions, Parameters governing human comfort, Various comfort indices, Choice of supply design conditions, Clean spaces.</p> <p>Load Analysis: Inside and outside design conditions, Load classification, Summer cooling loads, Solar terminology, Sun motion, Solar angles and their relationships, Calculation of solar radiation intensities, Solar heat gain through transparent bodies (e.g. glass), Transmission heat gain through building materials, Flywheel effect of building materials, Methods of calculating cooling load through building material, Loads due to human beings, Electric equipment's and appliances, Infiltration and ventilation loads, Product loads, Miscellaneous loads such as duct heat gain, Air leakage, Pumps, Winter heat load-computation of loads, Cooling and heating load calculation methods.</p> <p>Duct Design & Room Air Distribution: Pressure drop calculation for various types of duct, Enlargements, Contractions, Branch tube-offs etc., Duct design methods–velocity deduction, Equal friction and static regulation, Duct design procedure–dynamic loss coefficient method, Equitable length method, Case studies on duct design, Air distribution terminology, Air distribution system in rooms, Supply and return grills, Case studies.</p> <p>Air Conditioning Systems: Central and unitary air conditioning, Special features of residential, Commercial and industrial air conditioning system, Year round air conditioning, Instruments and Control: Temperature, Humidity, Air velocity measuring instruments, Thermostats, Humidistats, Bypass and damper control, Dew point control, Noise control, Pneumatic control etc.</p>	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Understand air conditioning system design.	
CO2: Utilize the fundamentals of Psychometrics for attaining course objectives.	
CO3: Solve various real life problems of air conditioning system.	
Books and References	
<ol style="list-style-type: none"> 1. Refrigeration and Air conditioning by M. Prasad, John Wiley & Sons. 2. Air conditioning engineering by W. Jones Butterworth-Heinemann. 3. Refrigeration and Air Conditioning by S. N. Sapali, PHI Learning Pvt. Ltd. 4. Heating, ventilation, and air conditioning by Parker Spitler, McQuiston, Wiley & Sons. 	

<p>Course Name: Exergy Analysis of Thermal Systems Course Code: ME-744 Course Type: Programme Elective-IV</p>	
Contact Hours/Week: 4L	Course Credits: 04
<p>Course Objectives</p> <ul style="list-style-type: none"> • To familiarize the students about the exergy and its applications in real life situations. • To carry out an exergy-economic analysis on the existed thermal system. 	
<p>Course Content</p>	
<p>Exergy Analysis of Simple Processes: Mixing and separation process of fluids of different temperature, Heat transfer across a temperature difference, Expansion and compression process, Combustion process.</p> <p>Exergy Destruction: Unavailable work referred to heat engine cycle, Refrigeration cycle, Heat pump cycle, Non-flow and steady flow process, Mechanism of exergy destruction, Modified Gouy-Stodola theorem, Concept of effective temperature.</p> <p>Exergy Analysis of Power Plant Cycles: Steam turbine power plants, External and internal irreversibility, Super heater, Reheater, Vacuum condenser, Regenerative feed water heating, Combined feed water heating and reheating gas turbine power plant, Regeneration and intercooler, Combined steam and gas turbine power plant.</p> <p>Exergy Analysis of Refrigeration & Air conditioning Systems: Joule-Thomson Expansion, Work- Producing Expansion, Optical intermediate cooling, Exergy analysis of air-conditioning application, Mixture of air and water vapour, Total flow exergy of humid air and liquid water, Evaporative cooling process and other aspects.</p> <p>Exergy-Economic Analysis: Fundamental of exergy-economic, Exergy costing of thermal components of steam and gas turbine, Boiler, Cogeneration system, Exergy analysis of renewable energy systems.</p>	
<p>Course Outcomes</p> <p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Identify and apply concepts, theorems of thermodynamics to the various thermal and fluid engineering system.</p> <p>CO2: Apply the concepts of exergy analyses in specific applications e.g. power stations, refrigeration installations, Cryogenic systems.</p> <p>CO3: Interpret and estimate exergy losses by, exergy calculations, exergetic efficiency, exergy charts.</p>	
<p>Books and References</p> <ol style="list-style-type: none"> 1. Advanced Engineering Thermodynamics by Adrian Bejan, John Wiley & Sons. 2. The Exergy Method of Thermal Plant Analysis by T J Kotas, Krieger Publishing Company. 3. Advance Thermodynamics for Engineers by D E Winterbore, Ali Turan, Kidlington, Oxford. 4. Fundamentals of Engineering Thermodynamics by Michel J Moran, Howard N Shapiro, Daisie D Boettne, argaret Bailey, Wiley. 	

Course Name: Design & Analysis of Solar Energy Systems	
Course Code: ME-745	
Course Type: Programme Elective-IV	
Contact Hours/Week: 4L	Course Credits: 04
Course Objectives	
<ul style="list-style-type: none"> • Understand the design concepts of solar systems. • Design and development of solar thermal systems. • Design of photovoltaic system and its components. 	
Course Content	
<p>Design Concepts of Solar Systems: System conceptual design, Design of components, Design of physical principles to the solar system based on application. Process includes idea generation, Concepts election and estimation, Design of major components and overall system design, Solar radiation data.</p> <p>Solar Thermal Energy Storage: Design aspects of solar thermal energy storage systems, Selection criteria of storage materials for heating and cooling applications, Selection of heat transfer fluid for heating and cooling applications, Design of latent heat thermal energy storage (LHTES) for solar process heating and power generation applications.</p> <p>Solar Photovoltaic System: Design of photovoltaic off-grid and grid-connected power systems, Design of system components -PV modules, Batteries, Charge controllers, Inverters, Auxiliaries, Performance analysis of a photovoltaic system, Using software codes for design of solar thermal and photovoltaic systems.</p> <p>Solar Heating and Cooling Systems: Design of solar thermal systems for water, Space heating, Cooling and power generation, F-Chart calculation method for sizing solar water and space heating systems, Design of non-focusing and focusing collectors.</p> <p>Performance Analysis: Performance analysis of various solar thermal systems, PV system and evaluation of solar thermal energy storage system, Selection of components and materials, Estimation of economics, Using software tools for design of solar thermal and photovoltaic systems, Case studies.</p>	
Course Outcomes	
<p>Upon successful completion of the course, the students will be able to</p> <p>CO1: Design & analyze the various types of solar systems & their components.</p> <p>CO2: Design & develop creative/novel thermal energy storage systems</p>	
Books and References	
<ol style="list-style-type: none"> 1. Solar Energy: Principles of Thermal Collection and Storage by S.P. Sukhatme, J. K. Nayak, Tata McGraw-Hill. 2. Solar Engineering of Thermal Processes by John A. Duffie William A. Beckman, John Wiley & Sons, Inc. 3. Solar Energy Engineering: Processes and Systems, Kalogirou. S.A, Academic Press. 4. Solar Energy Fundamentals and Modeling Techniques, Sen .Z, Turkey. 	

Course Name: **Design of Pumps & Turbines**

Course Code: **ME-746**

Course Type: **Programme Elective-IV**

Contact Hours/Week: **4L**

Course Credits: **04**

Course Objectives

- The course aims to impart knowledge of designing of various types of pumps and turbines
- To handle research level problems encountered in various pumps & turbines used in power generation units.

Course Content

General Theory of Hydraulic Machines: Hydro turbines, Pumps, Cavitation, Application of similarity consideration to hydrodynamic machines, Characteristics, Governing, Euler equation & Impact of Jet.

Design of Turbine: Hydraulic turbine, Impulse & Reaction Turbine, Work done & efficiency Estimation, Design aspects of Pelton wheels & Francis turbine runner, Axial flow turbine, Degree of Reaction & Draft tube.

Design of Pumps: Theoretical Pump characteristics, Effect of non-uniform velocity distribution, Axial entrance velocity, Blade outlet angle, Number of blade & length of blade, Slip factor, Design of radial flow impeller, Design of suction passage, Design of blade shape, NPSH, Design of axial pumps, Design of surge tank.

Reciprocating Pump: Data required for the design of reciprocating pump and design calculations. Operation and maintenance, Installation of pumping system. Testing of the pumping systems, Various methods based on the working fluid, Drive and pump etc., Maintenance of the pumps – Prediction and correction methods, Factors affecting the maintenance and their evaluation.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Carry out preliminary design of pumps & turbines.

CO2: Determine off-design behavior of pumps, turbines and relate it to changes in the velocity triangles.

Books and References

1. Design and Performance of Centrifugal and Axial Flow Pumps and Compressors by A. Kovats, Pergamon.
2. Centrifugal and Axial Flow Pumps by A.J. Stapanoff, John Wiley.
3. Hydraulic machines by V. P. Vasandani, Khanna Publishers.
4. Thermal and Hydraulic machines by G. S. Sawhney, PHI Learning Pvt. Ltd.

Course Name: Thermal Engineering Lab-I	
Course Code: ME-614	
Contact Hours/Week: 4P	Course Credits: 02
Course Content	
Course Objectives	
<ul style="list-style-type: none"> • To impart practical exposure of various thermal engineering systems. • To study the concepts, applications of the thermal engineering laboratory • To demonstrate and conduct experiments, interpret and analyze results of IC Engine testing. 	
Details of Experiments	
<ol style="list-style-type: none"> 1. To conduct Morse test on 4-stroke multi cylinder petrol engine to establish friction power, mechanical efficiency. 2. To determine the volumetric efficiency and mass flow rate of the single stage air compressor. 3. To understand the fabrication of thermocouple (T type) and its use for temperature measurement. 4. Measurement of pressure using projection manometer. 5. To calculate heat transfer rate and effectiveness of shell & tube heat exchanger. 6. To calculate heat transfer rate and effectiveness of double pipe heat exchanger. 7. To study the horizontal fire tube boiler. 8. Performance test on Pelton wheel turbine. 9. To study the characteristics of the double acting reciprocating pump test rig at variable speed. 10. Determination of various radiative properties such as emissivity and Stephan Boltzmann constant. 11. To determine the coefficient of performance of vapour absorption refrigeration systems. 12. To determine the coefficient of performance of individual cascades of cascade refrigeration systems. 	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Calculate the performance of internal combustion engines and air compressor.	
CO2: Draw and analyze performance curves of these machines/systems.	
CO3: Evaluate the Coefficient of performance various refrigeration systems.	
Books and References	
<ol style="list-style-type: none"> 1. Internal Combustion Engines by Ganesan.V, Tata McGraw Hill. 2. Internal Combustion Engine Fundamentals by J.B. Heywood, McGraw-Hill. 3. Refrigeration & Air conditioning by C.P. Arora, Tata McGraw Hill. 4. Turbo Compressors and Fans by S.M.Yahya, Tata McGraw-Hill. 	

Course Name: Thermal Engineering Lab-II	
Course Code: ME-624	
Contact Hours/Week: 4P	Course Credits: 02
Course Content	
Course Objectives	
<ul style="list-style-type: none"> • To impart computational exposure of various thermal physical situations. • To formulate problems followed by conducting simulations and interpretation of results. 	
Details of Experiments	
<ol style="list-style-type: none"> 1. Temperature distribution for steady state heat conduction. 2. Temperature distribution for unsteady state heat conduction by using explicit method. 3. Temperature distribution for unsteady state heat conduction by using implicit method. 4. Tri-diagonal matrix using Thomson algorithm. 5. Solution of Lid driven cavity problem. 6. Numerical solutions of quasi-one dimensional nozzle flows. 7. Modeling of flow around streamlined bodies using CFD solvers. 8. Modeling of flow around Bluff bodies using CFD solvers. 9. Simulation on natural convection flow problems using CFD solvers. 10. Simulation on mixed convection problems, laminar flow, problems using CFD solvers. 11. Simulation on mixed convection problems, turbulent flow, problems using CFD solvers. 12. Exercises on hydrodynamic and thermal boundary layer problems using CFD solvers. 	
Course Outcomes	
Upon successful completion of the course, the students will be able to	
CO1: Estimate temperature distribution for various systems.	
CO2: Introduction to CFD solvers.	
CO3: Solve various thermal related problems by using CFD solvers.	