VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Two Year Postgraduate Programme Leading to
Master of Technology (M.Tech.) Degree in
Mechanical Engineering with specialization in Machine Design

Implemented from the batch admitted in Academic Year 2014-15

PROGRAMME EDUCATIONAL OBJECTIVES

I. To achieve competency in the subject domain of advanced thermodynamics, fluid flow, heat transfer, design of heat exchange equipment required for Mechanical Engineering problems.

II. To implement analytical and computational skills to formulate and solve problems related to thrust area.

III. To carry out research and development activity and recognize the need for lifelong learning with ethical and professional responsibility.

Programme Outcomes:

The students should have –

PO 1 Ability to apply knowledge to solve complex problems in Thermal Engineering.

PO 2 Ability to design experiments, as well as to analyze and interpret data & results.

PO 3 Ability to design a system/process for sustainability.

PO 4 Ability to communicate effectively and develop leadership skills to function in multidisciplinary teams,

PO 5 Strong Desire and ability to do research work.

PO 6 Ability to use and update the techniques, skills, and modern engineering tools necessary for engineering practice.

PO 7 Ability to work with professional and ethical responsibility.

SEMESTER I

Scheme of Instruction				Scheme of Evaluation				
S. No	**Course Code**	**Course Title**	**L-T-P (Hours / week)**	**Credits**	**TA**	**IST**	**ESE**	**ESE Hours**
1.	ME5011S	Computational. Methods	3-1-0 =4	4	20	20	60	3
2.	ME5041S	Advanced Thermodynamics	3-1-0 = 4	4	20	20	60	3
3.	ME5042T	Advanced Fluid Dynamics	3-0-0=3	3	20	20	60	3
	ME5042P	Advanced Fluid Dynamics lab	0-0-2 = 2	1	100% CIE			3
4.	ME5043T	Conduction & Radiation	3-0-0 = 3	3	20	20	60	3
	ME5043P	Conduction & Radiation Lab	0-0-2 = 2	1	100% CIE			
5.		Program Elective Course 1	3-1-0 = 4	4	20	20	60	3
6.		Program Elective Course 2	3 -0 -0 = 3	3	20	20	60	3
		Program Elective Course2 Lab	0-0-2 = 2	1	100% CIE			
		Total	27	24				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, **IST**: In Semester Tests (comprise of average of two In semester tests), **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

SEMESTER II

Scheme of Instruction				Scheme of Evaluation				
S. No	**Course Code**	**Course Title**	**L-T-P (Hours / week)**	**Credits**	**TA**	**IST**	**ESE**	**ESE Hours**
1.	ME5015S	Research Methodology	3-1-0 =4	4	20	20	60	3
2.	ME5044S	Design of Heat Exchange Equipments	3-1-0 = 4	4	20	20	60	3
3.	ME5045T	Convective Heat Flow & Microfluidics	3-0-0 = 3	3	20	20	60	3
	ME5045P	Convective Heat Flow & Microfluidics Lab	0-0-2 = 2	1	100% CIE			3
4.	ME5046T	Computational Fluid Dynamics	3-0-0 = 3	3	20	20	60	3
	ME5046P	Computational Fluid Dynamics Lab	0-0-2 = 2	1	100% CIE			
5.		Program Elective Course 2	3 -0 -0 = 3	3	20	20	60	3
6.		Program Elective Course 3	3 -0 -0 = 3	3	20	20	60	3
		Program Elective Course 3 Lab	0-0-2 = 2	1	100% CIE			
7.	ME5801D	Technical Seminar	0-0-4	2	100% CIE			
		Total	30	25				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, **IST**: In Semester Tests (comprise of average of two In semester tests), **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation

List of Electives:

S. No	Course code	Course Title
Elective - I		
1.	ME5118S	System Modeling &Analysis
2.	ME5119S	Energy Conservation &Management
3.	ME5120S	Reliability Engg
Elective – II		
1.	ME5141T ME5141P	Advanced Refrigeration & Air Conditioning Advanced Refrigeration & Air Conditioning Lab
2.	ME5142T ME5142P	Advanced Internal Combustion Engines Advanced Internal Combustion Engines Lab
Elective – III		
1.	ME5143S	Cryogenics
2.	ME5144S	Gas Turbine & Propulsion
3.	ME5122S	Process Equipment Design
Elective – IV		
1.	ME5146T ME5146P	Energy Conversion Systems Energy Conversion Systems Lab
2.	ME5147T ME5147P	Finite Element methods Finite Element methods Lab
3.	ME5148T ME5148P	Advanced Turbo machinery Advanced Turbo machinery Lab

SEMESTER III and SEMESTER IV – Project work

Sr. No	Course Category	Course Title	Credits	Evaluation pattern	Semester
1.	ME6901D	Stage –I Presentation	4	Graded evaluation by a committee of at least two examiners including supervisor (guide)	III
2.	ME6902D	Stage –II Presentation	4	Graded evaluation by a committee of at least two examiners including supervisor (guide)	III
3	ME6903D	Stage –III Presentation	4	Graded evaluation by a committee of at least two examiners including supervisor (guide)	IV
4.	ME6904D	Presentation and Final Viva Voce	12	Graded evaluation by a committee of at least two examiners including supervisor (guide) and an external examiner	IV

Programme Name	**:**	**M. Tech. (Mechanical) All Branches SEMESTER –I**
Course Code	**:**	**ME5011S**
Course Title	**:**	**Computational Methods**
Outcomes		The students should be able to 1. Solve algebraic equations and Eigen value problems 2. Analyse data using interpolation and regression methods. 3. Apply concepts of vector spaces & different transformation techniques for problem solving. 4. Apply optimization, numerical methods , statistical methods to solve engineering problems

Sr. No.	Contents
1	**Algebraic Equations** Formulation and solution of linear system of equations Gauss elimination LU, QR decomposition iteration methods (Gauss-Seidal) Convergence of iteration methods.- Eigen Value problems
2	**Interpolation & Regression Methods** Newton's divided difference interpolation polynomials Lagrange interpolation polynomials Linear and non-linear regression multiple linear regression general linear least squares
3	**Transform Techniques** Vector spaces, Basis vectors, Orthogonal/Unitary transform, Fourier transform, Laplace transform
4	**Optimization Techniques for Engineers** Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function
5	**Numerical Methods Chapter** Trapezoidal rule, Simpson's $1/3^{rd}$ and $3/8^{th}$ rule. Newton Ralphson Method , Numerical differentiation & integration.
6	**Statistical Methods** Uncertainty analysis for data reduction ,Data Sampling

Tutorials:

Two tutorials on each module covering relevant engineering applications

Text Books:

01 “Numerical Methods for Engineers’, Steven C. Chapra and Raymond P. Canale, McGraw Hill

02 “Probability and Statistics in Engineering and Management Studies”, Hines and Montrogmery, John Willey

03 “Numerical Methods for Engineers”, Santosh Gupta, New age international publishers

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5041S**
Course Title	**:**	**Advanced Thermodynamics**
Course Outcomes		The student should be able to – 1. Apply the Laws of Thermodynamics to different systems. 2. Apply entropy principle to various heat flow systems. 3. Examine the performance of a Thermal System. 4. Evaluate thermodynamic system using classical and Statistical thermodynamics.

Sr. No.	Contents
1.	Introduction to thermodynamics. Fundamental concepts of statistical thermodynamics
2.	Classification & Properties of systems. Classical thermodynamics of phase equilibrium-open and closed systems
3.	Fundamental concepts of statistical thermodynamics. Thermodynamic properties and kinetics of perfect monatomic gases. Maxwell –Boltzmann, Fermi-Dirac and Bose – Einstein statistics.
4.	Second Law analysis of engineering processes: Availability and irreversibility of heat, a (closed) system and a stream in steady flow and their applications in thermal engineering, Thermodynamic relations for a single component system. Real gases and their equations of state; generalized charts for compressibility, enthalpy changes and fugacity. Single phase systems. Solutions and their types; mixtures of real gases; ideal and non-ideal liquid solutions.
5.	Concept & Evaluation of entropy, Clausius inequality, Principle of increase of entropy. Available energy, Availability, Exergy & Irreversibility, Enthalpy and entropy constants, Zeroth law, combined first & second law, Maxwell equations, Helmotz & Gibbs function, Whols expansion for excess, Gibbs energy equations of Van der Waal, Wilson and Renon equations for activity coefficient.
6.	Thermodynamics of small system: Gibbs equation of nano-system, statistical mechanics & thermodynamics property prediction, different approach to nanothermodynamics, surface thermodynamics, phase transition in nanoparticle.

Term work:

1. Assignments
2. Seminars/ Case studies

References:

1. C. L. Tien and J. H. Lienhard, "Statistical Thermodynamics", McGraw Hill Book Company, New York, 1979.
2. David R. Gaskell, Introduction to Thermodynamics of Material, Taylor & Francis (2002).
3. R. E. Sonntag and G. J. Van Wylen, "Introduction to Thermodynamics – Classical and Statistical", John Wiley & Sons, New York, 1982.
4. D.V.Ragone, Thermodynamics of Material, vol 1& 2, John Wiley & sons. (1994).

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5042T**
Course Title	**:**	**Advanced Fluid Dynamics**
Course Outcomes		The student should be able to – 1. Identify the significance of each term in the governing equations and simplify the governing equations for various problems. 2. Apply the fundamentals of kinematics and conservation laws to fluid flow systems. 3. Utilize exact and integral solutions of the boundary layer equations. 4. Analyse and apply the fundamentals of turbulent flow to various fluid flow systems. 5. Apply the principles of compressible flow to relevant systems.

Sr. No.	**Contents**
1	**Basic Concepts and Fundamentals** Continuum concept, properties of Fluids, Theoretical and experimental approach, Langragian and Eulerian description, types of flow, Velocity and stress field, Fluid Kinematics
2	**Governing Equations of Fluid Motion** Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equations, Navier-Stokes equations, Euler's equation, Bernoulli's Equation. Non-dimensional Navier-Stokes equations
3	**Exact solutions of Navier-Stokes Equations** Couette flows, Poiseuille flows, flow in a pipe, flow between concentric cylinders
4	**Potential Flows** Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag.
5	**Boundary Layer theory** Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct.

6	**Turbulent Flow** Introduction, Fluctuations and time-averaging, General equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows.
7	**Compressible Flows** Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

References:

1. Robert W. Fox, Alan T. McDonald, Introduction to Fluid Mechanics, Fifth Edition, John Wiley India, 2009.
2. Frank M. White, Fluid Mechanics, Tata McGraw-Hill, Singapore, Sixth Edition, 2008.
3. Frank M. White, Viscous Fluid Flow, Third Edition, McGraw-Hill, 2006.
4. John D. Anderson Jr, Modern Compressible Flow with Historical Perspective, McGraw-Hill, 1990.
5. Muralidhar K. and Biswas G., Advanced Engineering Fluid Mechanics, Second Edition, Narosa, 2005.
6. Pijush K. Kundu and Ira M. Cohen, Fluid Mechanics, Fourth Edition, Academic Press (ELSEVIER), 2008.
7. Schlichting H., Boundary Layer Theory, Springer Verlag, 2000.
8. Tennekes H. and Lumley J.L., A First Course in Turbulence, The MIT press, 1972.
9. S K Som, G Biswas, SumanChakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill Education

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5042P**
Course Title	**:**	**Advanced Fluid Dynamics Lab**

The student should be able to –

1. Measure pressure distribution, lift and drag around cylinders and Aerofoils.
2. Apply the fundamentals of kinematics and conservation laws to fluid flow systems.
3. Apply the principles of compressible flow.

Experiments

1. Drag & Lift Measurement of NACA2412 Aerofoil with variable Flap
2. Pressure distribution around the cylinder
3. Pressure distribution around the NACA2412 Aerofoil
4. Water Hammer & Pipe Surge
5. Cavitation Demonstration
6. Particle Image Velocimetry

Numerical solutions and comparison with analytical solutions for problems like

1. Couette flow
2. Poiseuille flow
3. Flow in a pipe
4. Flow between concentric cylinders
5. Boundary layer on a flat plate
6. Flow past a cylinder, sphere
7. Flow over an aerofoil
8. Supersonic flow over a wedge
9. Compressible flow in a nozzle

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5043T**
Course Title	**:**	**Advanced Heat Transfer (Conduction & Radiation)**
Course Outcomes		The student should be able to – 1. Apply laws of heat transfer and governing equations to a given thermal system. 2. Apply numerical techniques to complex conduction and radiation problems. 3. Employ computational methods for simulation of fin heat transfer and micro scale conduction problems. 4. Evaluate heat transfer in gas radiation and heat exchanger. 5. Design a thermal device for steady and unsteady state industrial applications.

Sr. No.	**CONTENTS**
1.	Review of heat transfer & fundamentals, Physical concepts of conduction and radiation
2.	Thermal properties- Heat capacity & Thermal conductivity
3.	Heat conduction - basic law, governing equations in differential form, solution methods, steady state, unsteady state problems-fins, moving boundaries.
4.	Steady, One dimensional heat conduction without heat generation – Plane walls
5.	Steady, One dimensional heat conduction without heat generation – Radial systems
6.	Steady, One dimensional heat conduction with heat generation
7.	Review of steady-state (1-D, 2-D, 3-D) and transient conduction and radiation heat Transfer
8.	Summary of solutions of classical heat conduction problems
9.	Heat conduction equations for Microscale dimensions and Microscale conduction applications
10.	Radiation basics
11.	Gas Radiation
12.	Introduction to radiation Black bodies
13.	Diffuse surface transfer, enclosures, view-factors

14.	Equation of radiative transfer; absorbing media
15	Coupled problems – radiation and conduction
16.	Overview of Macroscopic Thermal sciences – Radiation
17.	Advanced computational and analytical techniques for conduction, radiation.

References:

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, 1981.
2. M. Thirumaleshwar Fundamentals of Heat and Mass Transfer, Pearson Education Publication., 2009
3. A. F. Mills and V.Ganesan, "Heat Transfer", Pearson Education Publication., 2009.
4. Frank Kreith and Mark S. Bohn, "Principles of Heat Transfer", Harper and Row Publishers, 1986.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5043P**
Course Title	**:**	**Advanced Heat Transfer Lab (Conduction and Radiation)**
Course Outcomes		The student should be able to – 1. Use various thermal measurement devices for a thermal system. 2. Perform experiments on heat flow devices and examine the rate of heat transfer. 3. Apply computational techniques to find heat transfer & temperature distribution in thermal devices. 4. Evaluate heat transfer for different heat exchange devices. 5. Use modern engineering tools like CFD software to solve mix conduction and radiation problems.

Contents

1. Numerical Technique to find thermal resistance in a composite wall apparatus
2. Understandings of commercial software related to heat transfer problems and exposure for Fluent and Gambit through tutorials. Demonstration of creating various geometries faces, meshing of geometries.
3. Understandings concepts of various boundary conditions and its practical application in various geometries and post processing's for flow analysis results.
4. Demonstration of thermal gun and thermal camera used in various industrial thermal devices
5. Experimentation on variation of radiation heat flux using pyrometer.
6. computational and analytical techniques to find heat transfer in a pin fin geometry
7. Experimentation on computerized heat exchanger device to find heat dissipation rate
8. Experimentation on flow visualization around bluff bodies (cylindrical, square & triangular geometry).
9. To determine conduction & radiation heat transfer & findings temperature distribution over a flat plate.
10. Introduction & study of various components of particle image velocimetry.
11. Experimentation using particle image velocimetry to find heat flow in a composite slab apparatus.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5044S**
Course Title	**:**	**Design of Heat Exchange Equipments**
Course Outcomes		The student should be able to – 1. Compare the effect of operating parameters on performance of heat exchangers. 2. Select appropriate type of heat exchangers for the given application. 3. Evaluate the performance of various types of heat exchangers. 4. Design a suitable type of heat exchanger under the given constraints.

Sr. No.	CONTENTS
1	**Classification:** • Basic types of heat exchange deices. • Working principles of Shell-&-Tube, Spiral, Plate heat exchangers. • Advantages / limitations of various types of heat exchangers. • General guidelines for selection of heat exchangers.
2	**Basic Design of Heat Exchangers:** • Classification of heat exchangers. • Basic design methods, Theoretical analysis of parallel flow, counterflow, crossflow and multi-pass heat exchangers, LMTD Approach, Effectiveness-NTU Approach, Use of various charts for calculation of performance factors.
3	**Design of Double Pipe Heat Exchangers:** • Counterflow double pipe heat exchangers, calculation of Fouling Factor, calculation of Pressure Drop in pipes and annuli, • Kern method for design of Double Pipe heat exchangers. • Double Pipe heat exchangers in series-parallel arrangements.
4	**Design of Double Pipe Heat Exchangers:** • Heat exchanger tubes, joints, baffles, and their various configurations. • TEMA Standards and nomenclatures. • Heat Transfer Coefficients and Pressure Drop calculations, Kern method, Bell-Delaware method, Willis-Johnston method.
5	**Design of Plate Heat Exchangers:** • Plate heat exchangers – Gasketted, Spiral, Lamella • Plate heat exchangers – applications, advantages & limitations. • Theoretical design of Plate heat exchangers.
6	**Advances of Heat Exchanger Design:** • Compact heat exchangers, Regenerative heat exchangers. • Performance enhancement of heat exchangers, fouling and corrosion. • Testing, Maintenance and Evaluation of heat exchangers.

References:

1. Donald Q. Kern, Process Heat Transfer, McGraw-Hill Inc., 1965.
2. G. F. Hewitt, G. L. Shires and T. R. Bott, Process Heat Transfer, CRC Press, 1994.
3. W. M. Kays and A. L. London, Compact Heat Exchangers, McGraw-Hill Inc., 1964.
4. SadikKakac and Hongtan Liu, Heat Exchanger Selection, Rating and Thermal Design, CRC Press, 2012.
5. Arthur P. Frass, Heat Exchanger Design Handbook, Hemisphere Publishing Corporation, 2012.
6. Holger Martin, Heat Exchangers, Hemisphere Publishing Corporation, 1992.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5045T**
Course Title	**:**	**CONVECTIVE HEAT FLOW & MICROFLUIDS**
Course Outcomes		The student should be able to – 1. Illustrate convective heat transfer in thermal devices. 2. Analyse single phase and two phase heat transfer in thermal system. 3. Explore conservation equations and heat transfer in micro fluidics systems. 4. Develop the numerical technique to design heat flow devices using CFD software.

Sr.No.	CONTENTS
1.	Review of convection, external and internal fluid flow, convective heat transfer - conservation equations, boundary layer approximations.
2.	Unsteady Laminar and Turbulent Forced Convection in Ducts and on Plates, Forced convective laminar and turbulent flow solutions. Natural convection solutions, correlations
3.	Convection with body forces
4.	Two Phase Flow correlations
5.	Introduction to MEMS, theory of microfluidics, Flow in Microchannels, Overview of Macroscopic Thermal sciences – Convection
6.	Physics at the micrometric scale, molecular dynamics
7.	Hydrodynamics & thermal transfers in microfluidic systems
8.	Laminar convection – Internal flow, boundary-driven flow, Couette flow Poiseuille flow
9.	Convection heat transfer & Conservation Equations at microscale
10.	Single -phase heat transfer &Thermophysical properties at the microscale
11.	Microfluidic devices & applications: Micro Mixing, Microvalves, Micropumps

References:

1. Frank P. Incropera and David P. Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, 1981.
2. R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, " Transport Phenomena", John Wiley & Sons, 1994.
3. W. M. Kays and M. E. Crawford, "Convective Heat and Mass Transfer", McGraw Hill Inc., 1993.
4. Frank Kreith and Mark S. Bohn, "Principles of Heat Transfer", Harper and Row Publishers, 1986.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5045P**
Course Title	**:**	**CONVECTIVE HEAT FLOW & MICROFLUIDS LAB**
Course Outcomes		The student should be able to – 1. Apply numerical technique to heat transfer in internal and external flows. 2. Perform experiments on convection heat transfer devices to examine heat dissipation rate. 3. Evaluate heat transfer phenomenon and friction, pressure drop characteristics in micro fluidics devices. 4. Apply computational techniques, skills, and modern engineering tools like CFD software to solve complex problems.

Sr. No.	Contents
1.	Determination of heat transfer coefficient of flow over a bluff body
2.	Numerical simulation of free stream flow over a circular cylinder and demonstrating the effect of Reynolds number and vortex shedding in a pipe.
3.	Determination of boundary layer thickness in flow over a flat plate using concept of numerical analysis in external flow
4.	Numerical study of Internal flow in a pipe and study of boundary layer formation with uniform velocity and temperature profile at inlet.
5.	computational and analytical techniques to find heat transfer & pressure drop in a circular geometry
6.	Determination of Nusselt number, Prandtl number and heat transfer in a flow through pipe
7.	Study of velocity and temperature & pressure distribution at various sections of geometry.
8.	Study & demonstration of components of microfluidics
9.	Study of various components of particle image velocitymetry.
10.	Experimentation to find velocity & pressure variation using particle image velocitymetry

Programme Name	**:**	**M. Tech. (Mechanical) Thermal Engineering**	**SEMESTER – II**
Course Code	**:**	**ME5046T**	
Course Title	**:**	**Computational Fluid Dynamics**	

L	**T**	**P**	**Credits**	**TA**	**IST**	**ESE**	**Total**
3	-	-	3	20	20	60	100

Outcomes	The student should be able to – 1. Analyze methodologies used in CFD. 2. Apply finite volume method to heat transfer and fluid flow problems. 3. Develop computer codes for simulation of heat transfer and fluid flow problems.

Lesson Planning	
1	**Introduction:** Definition and overview of CFD, need, Advantages of CFD, Numerical vs Analytical vs Experimental, Applications of CFD, CFD methodology, grid independence, Verification and validation
2	**Governing equations of mass, momentum and energy :** Derivation, Discussion of physical meanings and presentation of forms particularly suitable to CFD, Boundary Conditions – Dirichlet, Neuman, Robbins, initial conditions, mathematical behavior of partial differential equations – Elliptic, parabolic & hyperbolic equations, impact on CFD
3	**Discretisation methods** – Introduction to Finite Difference Method, Finite Volume Method, Finite Element Method. Concepts of Convergence, consistency, stability. **Finite Difference method** – Introduction to finite differences, difference equation, Solution of discretised equations, Direct methods and iterative methods, Tri Diagonal Matrix Algorithm, iterative convergence
4	**Finite volume method for diffusion problems (Conduction)**: Steady state one dimensional heat conduction with or without heat generation, dealing with Dirichlet, Neumann, and Robins type boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction- Explicit, Crank-Nicolson , implicit schemes, two dimensional steady and unsteady heat conduction. Gauss-Seidal point by point and line by line TDMA methods.
5	**Finite volume method for Advection-diffusion problems (Convection-conduction)**: One dimensional convection-diffusion problem - Advection schemes-Central, first order upwind,

	hybrid, power law, Second order upwind, QUICK etc., Properties of advection schemes – Conservativeness, boundedness, transportiveness, False diffusion, Extension to two dimensional steady and unsteady advection - diffusion
6	**Solution algorithms for pressure velocity coupling in steady flows:** Staggered grids, SIMPLE, SIMPLER, SIMPLEC, PISO algorithms, unsteady flows
7	**Turbulence modeling :** Turbulence, its effect on governing equations, Reynolds averaged Navier-Stokes equations, introduction to turbulence modeling - DNS, LES, . k-ε , k-ω, RSM models
8	**Introduction to Grid Generation**: Structured and Unstructured Grids, General transformations of the equations, body fitted coordinate systems, Algebraic and Elliptic Methods, multi block structured grids, adaptive grids

References

1. S V Patankar, Numerical Heat Transfer and Fluid Flow, Special Indian 1st Edition, ANE BOOKS-NEW DELHI.

2. H K Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Second Indian Edition, Pearson Education, 2008

3. John. D. Anderson, Jr., Computational Fluid Dynamics - The basics with applications, McGraw-Hill Education (India) , 1st Edition

4. A.W. Date, Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.

5. Ferziger and Peric, Computational Methods for Fluid Dynamics, 3rd Edition, Springer, 2008

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5046P**
Course Title	**:**	**Computational Fluid Dynamics Lab**

The student should be able to –

1. Develop computer codes for simulation of heat transfer and fluid flow problems.

2. Implement of CFD process by using CFD software.

3. Evaluate data obtained from the numerical solution

To develop computer codes for

1. Steady state one dimensional heat conduction with or without heat generation, different boundary conditions, Multi-solid heat conduction, Non-linear Heat Conduction, Unsteady heat conduction, two dimensional steady and unsteady heat conduction.
2. One dimensional convection-diffusion problem to implement various advection schemes like - Central, first order upwind, hybrid, power law, Second order upwind, QUICK etc., two dimensional steady and unsteady convection – diffusion
3. To implement pressure velocity couplings like SIMPLE etc.

Exposure to CFD software for solving simple problems like

1. Laminar Pipe Flow
2. Turbulent pipe flow
3. Flow over a flat plate
4. Flow over an aerofoil
5. Laminar Convection
6. Turbulent Convection
7. Channel flow with backward facing step
8. Lid driven cavity

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5119S**
Course Title	**:**	**Energy Conservation and Management**
Course Outcomes		The student should be able to - 1. Recognise the concepts of basic measurement, instruments for measuring various parameters in energy systems and energy auditing. 2. Apply Energy Planning and forecasting techniques for performing energy analysis. 3. Illustrate the current energy scenario, challenge of climate change & peak oil, importance of energy conservation and need for alternative energy resources. 4. Integrate energy economics and relevance of sound energy policies for sustainable development.

Sr. No.	CONTENTS
1	**INTRODUCTION:** Energy Scenario -world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries - an overview. Peak oil. Energy conservation and energy efficiency – needs and advantages.
2	**POLLUTION FROM ENERGY GENERATION** Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, nuclear fuel cycle, radioactive wastes – treatment and disposal-Environmental pollution limits guidelines for thermal power plant pollution control- Environmental emissions from extraction, conversion, transport and utilization of fossil fuels- Green house effect- Global warming.
3	**ENERGY AUDITING AND FORECASTING** **Energy auditing** - Definition, need, types of energy audit methodologies, barriers. Role, Duties and responsibilities of energy managers and auditors. – Energy audit questionnaire - Energy Conservation Act 2003. **Energy forecasting techniques -** Energy demand – supply balancing, Energy models, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India.
4	**ENERGY CONSERVATION AND MANAGEMENT** Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies for – (a) Thermal utilities: operation and energy conservation (i)Boilers (ii) Thermic Fluid Heaters (iii)Furnaces (iv)Waste Heat

	Recovery Systems (v) Thermal Storage, A.C. & refrigeration systems; and (b) thermal energy transmission / protection systems such as Steam traps– refractories – optimum insulation thickness– insulation – piping design , optimizing the input energy requirements; Fuel & energy substitution.
5	**ENERGY ECONOMICS** Investment - need, appraisal and criteria, financial analysis techniques - break even analysis-simple pay back period, return on investment, net present value, internal rate of return, cash flows, DSCR, financing options, ESCO concept.
6	**ENERGY POLICIES** National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy- Carbon Trading- Renewable Energy Certification – CDM. The Sustainable Energy Utility (SEU) Model.

References:

1. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980.
2. YP Abbi and Shashank Jain. “Handbook on Energy Audit and EnviromentManagement”, TERI Publications, 2006.
3. Steve Doty, Wayne C. Tur ENERGY FORECASTING TECHNIQUES.
4. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)
5. R Loulou, P R Shukla and A Kanudia, “Energy and Environment Policies for a sustainable Future”, Allied Publishers Ltd, New Delhi, 1997.
6. http://ceep.udel.edu/wp-content/uploads/2013/08/2009_es_BSTS_SEU_model_DE_Wash-DC_Houck_Rickerson_2.pdf

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5141S**
Course Title	**:**	**Advanced Refrigeration & Air Conditioning**
Course Outcomes		The student should be able – 1. To evaluate the performance of various refrigeration systems 2. To design a suitable refrigeration system under the given constraints. 3. To illustrate various air conditioning principles and processes. 4. To devise suitable air conditioning system for given applications

CONTENTS:-

Sr.No.	**CONTENTS**
1	**Refrigeration:** • Definition of Refrigeration, Reversed Heat Engine Air Standard cycles, Reversed Carnot Cycle, Reversed Joule Cycle or Bell Coleman cycle, Refrigerator, Heat Pump, Performance parameters like Tonnes of Refrigeration (TR), Coefficient of Performance (COP), kW (power) per TR, TR per kW etc. • Application of various Air Standard Refrigeration cycles used for cooling Air-Craft cabins. Comparisons.
2	**Vapour Compression Refrigeration:** • Reversed Carnot cycle, actual Vapor Compression cycle. Comparison of VCC with Air Refrigeration cycles. • Multistaging, Cascade Refrigeration.
3	**Refrigerants:** • Refrigerants & their nomenclature, types and properties. Primary & Secondary refrigerants, Alternate refrigerants. • Ozone Depletion Potential (ODP) & Global Warming Potential (GWP), Montreal Protocol & Kyoto Protocol.
4	**Vapour Absorption Refrigeration:** • Binary mixtures, Construction of Enthalpy-Concentration Charts, Basic processes of binary mixtures, • Theory of construction of Rectification Column, Working of theoretical Vapour Absorption Refrigeration cycle. Ammonia-Water (NH_3 - H_2O) system, Lithium Bromide-Water ($LiBr$-H_2O) system.

5	**Study of Advanced Refrigeration Applications:** • Electrolux Refrigeration, Thermo-electric Refrigeration, Waste Heat Refrigeration, Cogeneration Refrigeration, Magnetic Refrigeration, Triple Fluid Refrigeration System , Steam Jet Refrigeration.
6	**Psychrometry:** • Definition of Air Conditioning, Psychrometry – Properties of moist air. • Theoretical Analysis, Construction and use of Psychrometric Charts.
7	**Psychrometric Processes:** • Psychrometric processes – Adiabatic mixing, Sensible heating / cooling, Humidification / Dehumidification, Bypass Factor, Apparatus Dew Point (ADP). Types of Sensible Heat Factors (SHF) like Room SHF, Grand SHF, effective SHF, Mixing of fresh air with recirculated air before & after AC.
8	**Air-Conditioners**: • Heating / Cooling Load Calculations, Summer / Winter AC, Air Distribution & Duct Design. • Year Round A.C., Split A.C., Central A.C., Comfort Air Conditioning- Effective Temperature, Comfort, Comfort Charts, Comfort Zone.

References:

Text Books:

1 Refrigeration & Air-Conditioning, Arora, Domkundwar, DhanpatRai Publications.
2 Refrigeration & Air-Conditioning, Manohar Prasad, New Age Intl. Publications.
3 Refrigeration & Air-Conditioning, C.P.Arora, Tata McGraw Hill.
4 R.A.C. Tables & Charts, Domkundwar, DhanpatRai Publications.
5 R.A.C. Tables & Charts, Manohar Prasad, New Age Intl Publications.

Reference Books :

1 ASHRAE Handbook.
2 Thermal Environmental Engineering, Threlkeld, Prentice-Hall Inc.
3 Refrigeration & Air Conditioning, Jordan &Priester, Prentice-Hall Inc.
4 Air Conditioning Engineering, Jones, Arnold ELBS
5 Air Conditioning Engineering, Jennings, Addison-Wesley Inc.

Programme Name	**:**	**F.Y. M. Tech. (Mechanical) (Thermal)**				**SEMESTER – I**	
Course Code	**:**	**ME5141P**					
Course Title	**:**	**Advanced Refrigeration & Air Conditioning Lab**					
L	**T**	**P**	**Credits**	**TW**		**ESE**	**Total**
-	**-**	**3**	**3**	**50**	**--**	**50**	**100**
Outcomes		The student should be able – 1. To evaluate the performance of various refrigeration systems 2. To design a suitable refrigeration system under the given constraints. 3. To illustrate various air conditioning principles and processes. 4. To devise suitable air conditioning system for given applications					

Course Contents	
1.	To conduct a trial on Water Cooler with Simple Vapour Compression Cycle, and analyse the effect of evaporative load with respect to the performance of the system in terms of Coefficient of Performance (COP).
2.	To conduct the performance trials on the Vapour Compression Refrigeration Tutor / Heat Pump Tutor by keeping : a. Compressor power constant. b. Condenser Pressure constant. **c.** Evaporator Pressure constant.
3.	To conduct a trial on Vapour Absorption Tutor for analyzing the working of various sub-assemblies of the Vapour Absorption Refrigeration System, and to analyse the effect of absorption efficiency on the Coefficient of Performance (COP) of the system.
4.	To analyse the effect of variation of Dry Bulb Temperature (DBT) and Wet Bulb Temperature (WBT) on the thermodynamic properties of moist air by applying the Psychrometric Principles to the same, and comparing with the values from Psychrometric Charts.
5.	To conduct the performance trials on the Air Conditioning Tutor for analyzing the following processes : a. Adiabatic Mixing of two streams.

	b. Cooling with dehumidification. c. Heating with humidification.
6.	Visit to a Refrigeration and Air-conditioning plant or Industry : Optional Objective : To make aware the students with practical industrial implementations of Principles of Refrigeration and Air Conditioning, along with manufacturing and assembly.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal Engineering**				**SEMESTER –I**	
Course Code	**:**	**ME 5013 T**					
Course Title	**:**	**Advanced Internal Combustion Engines**					
L	**T**	**P**	**Credits**	**TA**	**IST**	**ESE**	**Total**
3	-	-	3	20	20	60	100
Outcome		The student should be able – 1.Examine the effect of engine variables on the combustion process in S.I. and C.I. engines. 2.Analyze the performance of naturally aspirated and supercharged internal combustion engines. 3.Compare the performance of various sub systems employed in the engines. 4.Evaluate the data of engine emissions and suggest solutions.					

Content:

1	**Introduction and Classification of I.C. Engines:** Comparative study of two stroke and Four stroke engines. Classification based on other parameters. Applications.
2	**Cycle Analysis of I.C. Engines:** Air standard cycles, Fuel air cycles, Actual cycles of operation, Valve timing diagrams.
3	**S.I. Engines:** Induction system- Air intake, volumetric efficiency, factors influencing the volumetric efficiency. Carburetion - Theory of Carburetion. Simple carburetor, various systems of actual Carburetor. Types of Carburetors (refer mfg. Manuals of present day vehicles) Petrol Injection- Advantages of injection, MPFI systems Ignition System – Battery and Magneto Ignition Systems, Electronic Ignition Systems Combustion in S.I. Engines- Pressure - crank angle diagram, Stages of combustion, Ignition Delay, Flame Propagation, Afterburning. Abnormal Combustion – Auto ignition, Effects of auto ignition factors affecting combustion & auto ignition/detonation,. Control of abnormal combustion Principles involved in combustion chamber design, Types of combustion chambers used in S.I. engines.
4	**C.I. Engines:** Intake of air, volumetric efficiency, factors influencing the volumetric efficiency. Fuel Injection Systems - Types of fuel injection systems, viz. Common rail, individual pump, and distributor and unit injector systems. High pressure fuel injection pumps. Type of Nozzles. Necessity of Governor in Diesel engines. Combustion in C.I.Engines- Pressure–Crank angle diagram, combustion phenomenon in C.I. Engines, Stages of combustion, importance of delay period.

	Abnormal combustion, Knocking, Factors affecting combustion and knocking. Types of combustion chambers used in C.I. engines
5	**Supercharging/Turbo charging:** Objectives of Supercharging /Turbo charging, Effect of Supercharging / Turbo charging on power output & efficiency of engine. Methods of Supercharging / Turbo charging, Types of Superchargers/Turbochargers. Limits of Supercharging / Turbo charging.
6	**Performance Characteristics of S.I. & C.I. Engines:** Heat transfer in an engine, Losses, Unit air charge/ volumetric efficiency, Indicated efficiency, Mechanical efficiency, Brake thermal efficiency, Effect of load and speed on indicated, mechanical, brake thermal & volumetric efficiencies. Torque, Mean Effective Pressure, Specific Fuel consumption (Indicated and Brake parameters for all of these)Heat balance for an engine. Methods of determining indicated power of the engine.
7	**Air Pollution due to I.C. Engines:** Air/Fuel Ratio with the help of exhaust gas analysis, various pollutants and sources of pollution in the engine. Pollution control devices, EURO standards/ Bharat Standards.
8	**Alternate fuels and engines:** Alternate fuels for I.C. Engines, CNG, LPG, Stratified Charge and Wankel engines.
12	**Recent Developments in I.C. Engines.**

Text Books:

- E.E.Obert, "Internal Combustion Engines", Harper and Row Publishers, Based on Third Edition.
- V.Ganesan, "Internal Combustion Engines", Tata McGraw Hill 2003 Edition.

Reference Books :

- C.F.Taylor, "Internal Combustion Engines", Vol. I and II, MIT Press, 1985 Revised Edition.
- Richard Stone, "Internal Combustion Engines", Palgrave publications 1999 Third Edition.
- John Heywood, "Internal Combustion Engines", McGraw Hill company 2011 Indian Edition.
- C.R.Ferguson, A.T.Kirkpatrick, "Internal Combustion Engines", John Wiley& Sons(Asia), Second Edition.

<table>
<tr><td>Programme Name</td><td>:</td><td colspan="4">M. Tech. (Mechanical)
Thermal Engineering</td><td colspan="2">SEMESTER –I</td></tr>
<tr><td>Course Code</td><td>:</td><td colspan="6">ME 5013 P</td></tr>
<tr><td>Course Title</td><td>:</td><td colspan="6">Advanced Internal Combustion Engines Lab.</td></tr>
<tr><td>L</td><td colspan="2">T</td><td>P</td><td>Credits</td><td>ISE</td><td>ESE</td><td>Total</td></tr>
<tr><td>-</td><td colspan="2">-</td><td>2</td><td>1</td><td>50</td><td>50</td><td>100</td></tr>
<tr><td colspan="3">Outcome</td><td colspan="5">The student should be able –
1. Evaluate the performance of a naturally aspirated I.C.Engine
2. Evaluate the performance of a Supercharged I.C.Engine
3. Compare the subsystems used in I.C. Engines</td></tr>
</table>

List of Experiments:

- To dissemble an engine and study the internal details and different sub systems.
- To perform a Load Test on a CI engine, and evaluate the brake parameters' variation with respect to load.
- To perform a Heat Balance on a C.I. Engine, and to analyze the heat flow to various systems. To suggest improvements in the performance by reduction of heat losses.
- To perform a Load Test on an S.I. Engine, and evaluate the brake parameters' variation with respect to load.
- To perform a Speed Test on an S.I. Engine and to evaluate its performance with respect to speed.
- To perform a Morse Test on an S.I. Engine to find out the frictional power and indicated parameters of the engine, their variation with respect to load and speed.
- To perform a Load Test on a Turbocharged Engine, to evaluate the performance parameters and to compare all these with the performance of a naturally aspirated engine.

Assignments:

- Numerical problems based on Engine Design.
- Report on recent developments and current thrust areas in the field.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5143S**
Course Title	**:**	**Cryogenics**
Course Outcomes		The student should be able to– 1. Evaluate various gas liquefaction processes. 2. Examine air separation techniques. 3. Compare different cryogenic refrigeration systems. 4. Justify the use of vacuum and insulation for low temperature applications and instrumentation required. 5. Explore various applications of and the latest developments in cryogenic engineering.

Sr. No.	CONTENTS
1	**Introduction to cryogenic systems-** Historical Background and development, present state of affairs of cryogenic engineering.
2	**Properties of Engineering Materials-** at low temperatures, Thermal, Engineering and Magnetic properties of cryogens.
3	**Gas liquefaction** – Thermodynamically ideal system, Joule-Thomson effect, Adiabatic expansion, Actual liquefaction systems, Performance parameters, Critical components of liquefaction systems.
4	**Gas separation and purification systems** – Ideal gas separation system, separation of binary mixtures at cryogenic temperatures, Requirement of Purification, Purification systems at low temperatures.
5	**Cryogenic refrigeration systems** – Joule-Thompson Refrigeration systems, Expansion engine refrigeration systems, Philips refrigerators, G-M Refrigerators, Magnetic Refrigeration.
6	**Instrumentation for low temperatures** – Temperature, Pressure, Flow rate and Liquid level measurement.
7	**Cryogenic fluid storage and Handling systems** – Vessels and transfer systems.
8	**Insulation** – Special insulation requirements at low temperatures, insulating materials.

9	**Vacuum Technology in cryogenics**- Need and Implementation, various vacuum pumps.
10	**Applications of cryogenic engineering** – Various fields of application such as Superconducting devices, Space technology, Mechanical Design, Food preservation and Medicine.

References:

Text Books:

Cryogenic Systems –R. Barron Oxford University Press, Latest Edition.

Cryo-cooler Fundamental part-I and II - G. Walker Plenum Press New York

Reference Books :

Sterling cycle design manual- Martini W. NASA Report – 1978.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5146T**
Course Title	**:**	**Energy Conversion Systems**
Course Outcomes		The student should be able to – 1. Analyze various Energy Sources based on prospecting, extraction and resource assessment and their peculiar characteristics. 2. Design different energy conversion systems. 3. Demonstrate and design various renewable energy systems. 4. Discuss integrated energy approach and sustainable energy policies.

Sr. No.	CONTENTS
1	**Review of Energy Sources** • Conventional & Renewable Energy • Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics.
2	**Thermal and Mechanical Energy.** • Conversion of Thermal Energy to Mechanical energy & Power. • Steam turbines, Gas turbine, Nuclear Fusion and Fission • Combined cycle analysis –Inter-cooling, reheating and regeneration-gas turbine cooling. • Design for high temperature -Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam -STAG combined cycle power plant -Influence of component efficiencies on cycle performance
3	**Co-generation, Tri-generation & Waste Energy Recovery** • Co-generation & Tri-generation: Definition, need, application, advantages, classification, saving Potential. • Waste Heat Recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices.
4	**Solar energy** The Sun – Production and transfer of solar energy – Sun-Earth angles – Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation – Solar thermal collectors – General description and characteristics – Flat plate collectors – Heat transfer processes – Short term and long term collector performance – Solar concentrators – Design, analysis and performance evaluation.
5	**Energy from biomass** Sources of biomass – Different species – Conversion of biomass into

	fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion – Properties of biomass – Biogas plants – Types of plants – Design and operation – Properties and characteristics of biogas.
6	**Other Renewable Energy Sources** Geothermal energy - Availability, system development and limitations Ocean Energy - Ocean thermal energy conversion. Wave and tidal energy.
7	**Integrated energy systems** Wind – Solar Hybrid, Wind-Solar-Hydro Hybrid. Integrated approach of energy system design.

References:

1. Principles of Energy Conversion: A.W.Culp (McGrawHill International.)
2. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications).
3. Boilers –Types, Characteristics and functions –Carl D. Shields (Mcgraw Hill book).
4. Renewable Energy Sources – John Twidell and A. D. Weir (ELBS Publication).
5. Solar Energy – S. P. Sukhatme, J. K. Nayak (The McGraw Hill Publication)
6. Solar Power Engineering – B. S. Magal (Tata McGraw Hill Publication)

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5146P**
Course Title	**:**	**Energy Conversion Systems Lab**

The student should be able to –

1. Analyze and evaluate various Energy Sources based on prospecting, extraction and resource assessment and their peculiar characteristics.
2. Design different energy conversion systems.

Following experiments be conducted in the laboratory

1. To demonstrate and measure solar radiation on horizontal surface by using pyranometer.
2. To demonstrate working of solar flat plate water collector.
3. Performance testing of Solar Water Collector
4. Characteristics of Solar photovoltaic devices
5. Testing of Gasifier
6. Finding Calorific Value of Fuels
7. To demonstrate working of (i) solar concentrating collector, (ii) solar dryer, (iii) solar assisted refrigeration and air conditioning plant.
8. To demonstrate working of (i) solar paraboloid concentrating collector, (ii) solar still and solar pump, (iii) Box type solar cooker and paraboloid concentrating cooker, and (iv) solar PV power plant used for campus electrification.
9. To demonstrate working of wind mill

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – I**
Course Code	**:**	**ME5118S**
Course Title	**:**	**SYSTEM MODELIING AND ANALYSIS**
Course Outcomes		The students should be able to - 1. Model Mechanical, electro-mechanical, hydraulic and pneumatic systems. 2. Estimate and evaluate steady state and transient response for various input conditions. 3. Use numerical and state space approach for finding solutions.

SR.NO.	CONTENT
1	**Mathematical Modelling Mechanical Elements** • Introduction, Inertia, stiffness and damper and Mathematical Modelling of Mechanical System, Vehicles, Articulated Vehicle and other Mechanical System. Modelling of Electro Mechanical System
2	**The Laplace transform** • Introduction, Complex Numbers, Complex Variables, and Complex Functions, Laplace Transformation, • Inverse Laplace Transformation, Solving Linear, Time-Invariant Differential Equations
3	**Mathematical Modeling Hydraulic Elements and Systems** • Pneumatic Element and System, Transfer Function Representation, Block Diagram, Step variable representation, Matrix Equation.
4	**Numerical and other solution Methods of Differential and step variable equation**
5	**Transient Response of First and Second order system** Steady State response, Step response, ramp response, Impulse response, sinusoidal response, Input Convolution Integral, Stability of System.

TERMWORK

1. Assignments
2. Seminar

REFERENCE BOOKS

1. Dynamic system Modelling and Analysis-Hung V Vu &R.S.Esfandi
2. System Dynamics-k.Oggata
3. Control Ssytem Engioneriing-I.J. Nagrath & M.Gopal

4. System Dynamics-WillianJ.Palm III
5. Vehicle Dynamics-Ellis
6. Vehicle Dynamics-Steed
7. Vehicle Dynamics-Gellips

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER –I**
Course Code	**:**	**ME5120S**
Course Title	**:**	**Elective – I** **Reliability Engineering**
Outcomes		The students should be able to - 1. Analyse the interference between strength and stress, or life data for estimating reliability; 2. Apply the appropriate methodologies and tools for enhancing the inherent and actual reliability of components and systems, taking into consideration cost aspects; 3. Use statistical tools to characterise the reliability of an item 4. Conduct life test plans for reliability validation.

SR.NO.	CONTENT
1	**Modelling of Life Distribution Functions** Quantification of reliability. Parameters of reliability: hazard rate and MTTF (for non-repairable items), failure rate and MTBF (for repairable items). Common failure patterns of systems and components; the bathtub curve for instantaneous failure rates. The memoryless property of items with a constant failure rate. Two- and three-parameter Weibull models.
2	**Failure Mechanisms** Stress-strength interference as a cause of failure. Approaches to minimise the chance of interference: safety margin, improving process capability, screening of items, and curtailment of load distribution.
3	**Modelling of System Reliability** Reliability block diagrams. Series and parallel configurations; use of the Bayesian approach. Use of redundancy to improve reliability. Active and standby redundancies.
4	**Reliability Design** Reliability programs. Reliability prediction in the preliminary design stage; the component count approach. Use of the component manufacturer’s data and computer packages for reliability prediction. Simplification, derating, and use of redundancy. Fault tree analysis; failure modes, effects, and criticality analysis; development testing; failure reporting and corrective action systems; reliability growth models.
5	**Analysis of Life Data and Reliability Testing** Non-parametric estimation of reliability functions. Parametric analysis of life

	data – probability plots of ungrouped and grouped data. Weibull analysis: parameter estimation, censored data, confidence limits, and Bq life. Hazard plots. Reliability validation tests, MIL-STD-781: the OC curve, discrimination ratio, producer's and consumer's risks. Failure truncation, time truncation, PRST. Confidence intervals for MTBF. Sudden death tests. Environmental testing. Accelerated tests.

TERM WORK

1. Assignments
2. Seminar

REFERENCE

1. Andrew K.S. Jardine and Albert H.C. Tsang, 2013, *Maintenance, Replacement and Reliability: Theory and Applications*, 2nd edition, CRC Press
2. O'Connor, D.T., 2002, Practical Reliability Engineering, 4th edn, Wiley
3. Elsayed, Elsayed A, 2012, Reliability Engineering, 2nd edition, John Wiley

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5147T**
Course Title	**:**	**FINITE ELEMENT METHODS**
Course Outcome:		The student should be able to– 1. Formulate numerical model for a given system. 2. Obtain numerical Solutions for boundary value problems. 3. Solve mechanical engineering problems using finite element methods

Sr.No.	CONTENTS
1	**Introduction to Finite Element Analysis** Introduction,Basic concept of Finite Element analysis,Discretization of continuum,Stiffness Matrix and Boundary Conditions,Introduction to elasticity ,Plane Stress and Plain strain Problem
2	**Finite Element Formulation Techniques** Virtual Work and variationalprinciple,Variational Formulation of Boundary Value problem, VariationalMethod such as Ritz and weighted Residual methods. Galerkin Method Potential Energy Approach, Displacement Approach
3	**Element Properties** Natural coordinates, Triangular Elements Rectangular Elements,Lagrange and Serendipity Elements,Solid Elements Isoparametric Formulation Stiffness Matrix for IsoparametricElements,Numerical Integration
4	**Displacement Models** Convergence requirements,Shapefunctions,Element stresses and strains Strain—Displacement Matrix for Bar Element ,Strain Displacement Matrix for CST Element ,Strain Displacement Relation for Beam Element
5	**Analysis of Frame Structure** Stiffness of Truss Members,Analysis of Truss,Stiffness of Beam Members Finite Elements analysis of Beam
6	**FEM for Two Dimensional Solids** Constant and Linear Stain Triangle. Rectangular Elements,Finite Element Formulation for 2D elements. Axisymmetric Elements.Finite Element Formulation of Axisymmetric Elements Heat Transfer by conduction and convection for one dimensional and two dimensional elements,
7	**Dynamic Analysis Using FEA** Introduction,Vibration Problems Equation of motion Based on weak form and Lagrange's Approach,Consistent and Lumped ass Matrices,Properties and Solution of Eigen Value Problems Transient Vibration Analysis ,Thermal transient-Unsteady heat Transfer in a Pin-Fin
8	**Non Linear Analysis** Introduction,Geometric and Material Non Linearity,Stability Problems Elastoplastic analysis by FEM

TERMWORK

1. Assignments
2. Seminar

REFERENCE BOOKS

1.FiniteElemenet Analysis By S.S.Bhavikatti,New Age International Publication
2. Introduction to FEM by Desai and Abel
3. The Finite Element Method for Solid and Structural Mechanics - Zienkiewicz& Taylor,Elsevier Publications
4. Finite Element Analysis by J.N.Reddy,McGraw Hill Book Co.
5. Finite Element Method in Engineering by S.S.Rao,Pergamon Press
6. Textbook on Finite Element Analysis by P.Sheshu,Prentise Hall Publications
7. Finite Element Analysis By Bathe and Wilson
8. Introduction to Finite Element Analysis by T. *Chandrupatla* and A. D. Belegundu, Prentice Hall
9. Finite Element Modeling For Stress Analysis for Robert D.Cook , John Wiley & Sons.
10.Computational Elasticity by Mohammad Ameen, Narosa Publishing House.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5741P**
Course Title	**:**	**FEM Lab**

Course outcomes
1. Use commercial FEA software, to solve problems related to mechanical engineering.

CONTENTS:-

Assignment No.	**CONTENTS**
	Structural Analysis
1	1-D Element Problems –Linear Static Analysis
2	2-D Element Problems – Linear Static Analysis
3	3-D Element Problems – Linear Static Analysis
4	Free Vibration Analysis on Beam, Bars ,Plates
5	Non-Linear Analysis of 1-D Element Problems Like Beams,Bars
	Thermal Analysis(Conduction,Covection and Insulation Boundary Conditions.
6	1-D Element Problems-Steady state And Transient Analysis
7	2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8	3-D Element Problems Steady State Analysis
9	Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Note:-Well Reputed FEA software like Hyper Mesh /Ansys Will be used for the above mentioned Assignments.

Assessment:-
1.TermworkAssessment based on the submission (Softcopy and Hard Copy) of the above assignment
2.ESE (Practical Examination)Will be online type based on the Application of above assignment using HyperMesh /AnsysSoftwares.

Reference Material:
1.Finite Element Analysis using Ansys 11.0 by Paleti Shrinivas, KrishaChaitnaySambana,Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by SaeedMoaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications inEngineering using ansys® by ErdoganMadenci,IbrahimGuven
5. Practicle Finite Element Analysis by NitinGokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software.
8. Tutorial of Ansys Software.

Programme Name	**:**	**M. Tech. (Mechanical) Thermal SEMESTER – II**
Course Code	**:**	**ME5122S**
Course Title	**:**	**Elective III – Process Equipment Design**
Course Outcomes		Students should be able to – 1. Design pressure vessels subjected to internal and external pressure. 2. Design special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads) 3. Examine other requirements of equipment fabrication and testing.

SR. NO..	CONTENTS
1	Type of vessels and factors influencing the design of vessels. classification of vessels such as tank, flat, bottomed and vertical cylinder tank, vertical cylindrical and horizontal vessels with formed ends as well as spherical or modified spherical vessels.
2	Criteria in vessel design. Elastic bending, plastic instability, cyclic loading stress reversals. Brittle rupture and creep rupture corrosion.
3	Design of simple vessels of different configuration. General proportions and lay-out. Vents, tapping and flanges.
4	Design of tall vertical vessels and supports
5	Elementary heat exchanger design.

Term work

1. Assignment
2. Seminar

Reference Books

1. "Pressure vessels design and practice", By: SomnathChattopadhyay. Publication: CRC Press. Ed: 2005
2. "Overview of pressure vessel design", By: Vincent A. Carucci. Publication: ASME International
3. "Process equipment design", By: Brownell and Young. Publication: Wiley Eastern Limited. Ed:1959, sixth reprint Sept 1991.
4. "Review of code for pressure vessels, IS 2825 as compared to ASME/BS/ADMerkblatter", By: N K Roy. Publication: Journal for Process Equipment & Piping Technology. Vol 1, No 1, June 1994
5. "A special report : Worldwide pressure vessel codes". Publication: Hydrocarbon
6. Processing, Dec 1978.
7. ASME Section VIII Div-1, 2 & 3 Ed. 2010 Addenda 2011a.
8. "Theory & Design of Pressure Vessels", By: John F Harvey, 15th Edition, Van Nostrand Reinhold Company Ltd.
9. "Pressure Vessel Design Handbook" By H. Bedner
10. Pressure Vessel Design Manual – Dennis Moss