DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE

&

DETAILED SYLLABUS

For

M.TECH

SPECIALIZATION

IN

HEAT POWER ENGINEERING

(Effective from 2019-20)

VEER SURENDRA SAI UNIVESITY OF TECHNOLOGY

BURLA, SAMBALPUR

PIN-768018

PEOs and POs of M.Tech. in Heat Power Engineering (HPE)

PROGRAMME SPECIFIC OUTCOMES (PSO)

PSO: Analyze the problems and solve them by applying engineering knowledge with a multidisciplinary approach in the area of thermal and fluid science, find out cost effective and optimum design for sustainable growth.

Programme Educational Objectives (PEOs):

- To enhance the fundamentals and the knowledge-base of students in thermal engineering and to make capable for effectively analyzing and solving the problems associated in this area.
- To encourage students to take up real life and research related problems and to create innovative solutions of these problems through systematic analysis and design.
- To inculcate teamwork, communication and interpersonal Skills adapting to changing environments of technology.

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Program Outcomes (POs):

- Ability to demonstrate sound domain knowledge in design and operation of various thermal systems to select optimal feasible solution considering safety, environment and other realistic constraints.
- Ability to design and conduct experiments in thermal engineering, as well as to organize, analyze and interpret data.
- Ability to demonstrate skill of good researcher to work on a particular problem starting from scratch to perform literature review, methodologies, techniques, tools, and conduct experiments and/or numerical simulations.
- Ability to demonstrate skills in latest engineering tools, software and equipments to analyze and solve engineering problems.
- Student will be able to demonstrate skills of presenting research work unequivocally before scientific community.
- Student will be able to understand professional, legal and ethical issues and responsibilities.

Semester I

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-1		Advanced Fluid Mechanics	3	0	0	3
2	Core-2		Conduction and Radiation Heat Transfer	3	0	0	3
3	PE-1		1. Advanced Refrigeration Engineering 2. Finite Element Modeling in Thermal Engineering 3. Turbulence Modeling	3	0	0	3
4	PE-2		1. Gas Dynamics 2. Advanced IC Engines 3. Solar Engineering	3	0	0	3
5	Common		Research Methodology & IPR	3	0	0	3
6	Lab-1		Thermo-fluids Lab-I	0	0	3	2
7	Lab-2		Numerical Simulation Lab	0	0	3	2
8	Audit -1 (Any one)		1. Constitution Of India 2. Stress Management By Yoga 3. Pedagogy Studies				
Total Credits							**19**

Semester II

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Core-3		Advanced Engineering Thermodynamics	3	0	0	3
2	Core-4		Convective Heat and Mass Transfer	3	0	0	3
3	PE-3		1. Cryogenic Technology 2. Thermal System Simulation and design 3. Computational Fluid Dynamics	3	0	0	3
4	PE-4		1. Introduction to Two-Phase Flow 2. Air Conditioning Engineering 3. Micro fluidics	3	0	0	3
5	Common		Minor project & Seminar	0	0	2	2
6	Lab-3		Thermo-fluids Lab-II	0	0	2	2
7	Lab-4		Research Seminar	0	0	2	2
8	Audit -2 (Any one)		1. English For Research Paper Writing 2. Value Education 3. Personality Development Through Life Enlightenment Skills				

Total Credits	18

Semester III

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	PE-5		1. Experimental Techniques in Thermal Engineering 2. Computational Gas Dynamics 3. Gas Turbine and Jet Propulsion	3	0	0	3
2	OE-1		1. Non-conventional energy 2. Matrix Computation 3. Smart Materials	3	0	0	3
3	Project		Dissertation (Phase-I)	0	0	10	10
Total Credits							16

Semester IV

Sl. No.	Core/ Elective	Subject Code	Subject Name	L	T	P	Credits
1	Project		Dissertation (Phase-II)	0	0	16	16
Total Credits							16

GRAND TOTAL CREDITS: 19+18+16+16= 69

Audit course 1 and 2:

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

ADVANCE FLUID MECHANICS

L-T-P:3-0-0 Credit-3

Course Objectives:

- To introduce fundamental concepts of fluid mechanics and derive the N-S equations for compressible flow.
- To find exact solutions of NS equations for some special cases.
- To find solutions for slow viscous flows and to introduce the concept hydrodynamic stability
- To introduce the concepts of boundary layer and find exact and approximate solutions for selective problems.
- To introduce the concept of turbulence and to be familiar with various turbulence modelling.

Course Contents:

MODULE 1: **(8 Hours)**

Concept of continuum and definition of a fluid, Body and surface forces, stress tensor, principle of local stress equilibrium, Scalar and vector fields, Eulerian and Lagrangian description of flow. Motion of fluid element: translation, rotation and deformation; vorticity and strain-rate tensors. Continuity equation, Cauchy's equations of motion, Reynold's Transport theorem. Constitutive equations-Stokes law of viscosity. Derivation of N-S equations for compressible flow

MODULE 2: **(6 Hours)**

Exact solutions of N-S equations: plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between twoconcentric rotating cylinders, Stokes first and second problems,Pulsating Flow between Parallel Surfaces, stagnation-point flow, Flow in convergent-divergent channels. Flow over a Porous wall

MODULE 3: **(5 Hours)**

Slow viscous flow: Stokes and Oseens approximation, Uniform flow Past a Sphere, theory of hydrodynamic lubrication.

Introduction to hydrodynamic stability, Orr-Sommerfeld equation, neutral curve of linear stability for plane Poiseuille flow.

MODULE 4: **(5 Hours)**

The Boundary-Layer Equations, Blasius Solution, Falkner-SkanSolutions, Flow Over a Wedge, Stagnation-Point Flow, Approximate Solution for a Flat Surface, General Momentum Integral, Boundary-Layer Separation, Stability of Boundary Layers

MODULE 5: **(6 Hours)**

Physical and Mathematical Description of Turbulence, The Reynolds Equations of Turbulent Motion, The Two-Dimensional Turbulent-Boundary-Layer Equations, Velocity Profiles: The Inner, Outer, and Overlap Layers, Turbulent Flow in Pipes and Channels, The Turbulent Boundary Layer on a Flat Plate,Turbulence Modeling in Two-Dimensional Flow, Analysis of

Turbulent Boundary layers with Pressure Gradient,Free Turbulence: Jets, Wakes, and Mixing Layers.

Text Book:

1. Viscous Fluid Flow by Frank M White (McGraw-Hill)
2. Fundamental Mechanics of Fluids by I.G Currie (CRC Press)

Reference Books:

1. Incompressible flow by R L Panton(John Wiley & Sons)
2. Fluid Mechanics, P.K. Kundu, I.M. Kohen & D.R. Dowling, Academic Press
3. An Introduction to Fluid Dynamics by G K Batchelor (Cambridge University Press)
4. Boundary Layer Theory by H Sctllichting (McGraw-Hill)

Course Outcomes:

- On successful completion of the course, the student will be able to
- Learn the details of the N-S equation derivation and related concepts.
- Solve practical problems using N-S equation.
- Solve low Reynolds number flow problems.
- Understand the concept of boundary layer theory
- Apply turbulence modelling to practical problems.

CONDUCTION AND RADIATION HEAT TRANSFER

L-T-P:3-0-0 Credit-3

Course Objectives:

- Impart knowledge on steady and transient Conduction
- Study on phase change problems
- Study of unsteady conduction
- To impart knowledge about Radiation and its effects
- Radiation in transparent and participating medium in different enclosure

Course Contents:

MODULE 1: (8 Hours)

Introduction to conduction: Derivation of energy equation for conduction in three dimensions – Initial and boundary conditions.

Solution of simple problems in steady state conduction with analytical solutions – Concept of electrical analogy – fin heat transfer and concept of fin efficiency and fin effectiveness.

Unsteady conduction: Concept of Biot number – Lumped capacitance formulation – simple problems – unsteady conduction from a semi-infinite solid- solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables and charts.

MODULE 2: (8 Hours)

2D steady conduction and phase change problems: Laplace equation – solution by variable separable method – concept of superposition and homogeneous boundary conditions.

Phase change problems – The Stefan and Neumann problems – analytical solutions.

MODULE 3: (6 Hours)

Importance of radiation, Mechanism of radiation, Electromagnetic spectrum, Concept of black body, derivation of black body radiation laws from first principles – Planck's law, Stefan Boltzmann law, Wien's displacement law, Universal black body function, F function charts.

MODULE 4: (4 Hours)

Radiative properties of non-black surfaces: Spectral directional emissivity, definition of total and hemispherical quantities, hemispherical total emissivity. Spectral directional absorptivity, Kirchoff law, directional and hemispherical absorptivity, hemispherical total absorptivity, View factors.

MODULE 5: (4 Hours)

Enclosure with Transparent Medium – Enclosure analysis for diffuse-gray surfaces and non-diffuse, non-gray surfaces, net radiation method.

Enclosure with Participating Medium - Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation

Text Books:

1. Conduction Heat Transfer, D. Poulikakos, Prentice Hall, 1994.
2. Thermal Radiation Heat Transfer, R. Siegel and J. R. Howell, Taylor & Francis, 2002.

Reference Books:

1. Heat Conduction, S. Kakac and Y. Yener, Taylor and Francis, 1994.
2. Conduction Heat Transfer, V.S. Arpaci, Addison Wesley, 1996 (Abridged edition Ginn press 1998)
3. Heat Transfer, A.J.Chapman, Macmillan, 1984.

Course Outcomes:

- Ability to apply the knowledge in analyzing the heat transfer performance for thermal systems
- Analytical and numerical analysis with respect to conduction and radiation for different geometry
- To be able to deal with phase change problems and unsteady real conditions while designing of heat transfer devices
- To be able to analyze and solve problems related to radiation and its effects
- To gain knowledge about heat transfer in different enclosures

ADVANCED REFRIGERATION ENGINEERING

L-T-P: 3-0-0 Credit-3

Course Objectives:

- To impart knowledge on refrigeration systems
- Understand vapour compression refrigeration and vapour absorption system
- To make students familiar with the principles governing thermodynamics and heat transfer and entropy
- Applications of refrigeration system and use of steam tables in the analysis of engineering devices and systems
- To provide an understanding of thermodynamic functions to solve practical problems

Course Contents:

MODULE-1 (8 Hours)

Thermodynamic properties of pure and mixed refrigerants and their Selection: Recapitulation of thermodynamics of refrigeration systems, Refrigerants: Introduction, Desirable properties of an Ideal Refrigerant, Physical, Chemical & thermodynamic properties of a refrigerant, Classification of Refrigerants: Primary & Secondary, Designation System of Refrigerants, Properties of Refrigerants, Uses of Important Refrigerants, Secondary Refrigerants – Brine

Vapour compression Refrigeration system: Analyis of Theoretical vapour Compression cycle, Types of vapour Compression cycles, Representation of the cycle on P-H, T-S and P-V diagrams, Simple Saturation Cycle, Sub-cooled cycles and superheated cycle, Effect of suction and discharge pressure on performance. Actual Vapour compression Cycle, Use of flash coolers, Advantages and disadvantages of Vapour Compression Systems

MODULE-2 (8 Hours)

Multistage compression systems: Introduction, Methods of improving C.O.P – Optimum Interstage, Pressure for Two-Stage Refrigeration System, Single load systems, Multi load systems with single Compressor, Multiple Evaporator and Compressor systems. Dual Compression systems

Vapour Absorption Refrigeration system: Introduction, simple vapour Absorption system, Practical Vapour Absorption System, Advantages of Vapour Absorption sytem over vapour compression system. Coefficient of Performance of an Ideal Vapour Absorption Refrigeration System. Electrolux (Ammonia-Hydrogen) Refrigerator, Lithium Bromide Absorption Refrigeration System

MODULE-3 (4Hours)

Ejector refrigeration systems: Principle and working, Advantages & disadvantage over existing systems, Alternative ejector types, Rotodynamic ejectors

Vortex tubes: Principle of working, Components, Phenomenon of energy transfer in vortex tubes, Analysis of temperature drop, adiabatic efficiency and COP, Advantages & applications

MODULE-4 (5Hours)

Principle of liquefaction of gases: Isentropic expansion, Free, Irreversible expansion, Joule Thompson co-efficient, Inversion temperature, Linde-Hampson System for liquefaction of air, hydrogen & helium, Low temperature applications

Solid ice production: Solid Carbon-dioxide as a refrigerant, Advantages & disadvantages, Manufacture of Solid Carbon-dioxide or dry Ice, , Use of water and flash intercooler for dry ice production

MODULE-5 (5 Hours)

Expansion devices - Capillary tubes, Automatic and thermostatic expansion valves, Design of capillary tubes

Thermal Design of evaporators & Condensers, Magnetic refrigeration systems, Analysis and thermal design of reciprocating centrifugal and screw compressors, Computer simulation of refrigerant compressors.

Textbooks:

1. C.P. Arora, Refrigeration & Air conditioning (TMH Publication)
2. Domkundwar & Arrora: Refrigeration & Air conditioning (Dhanpat Rai & Sons)

Reference Books:

1. Stoecker and Zones: Refrigeration & Air conditioning (Mc Graw Hill)
2. Monohar Prasad: Refrigeration & Air conditioning(EWP)
3. A text book of Refrigeration and Air-conditioning by R.S. Khurmi and J.K. Jai, S.Chand & Co.

Course Outcome:

- A fundamental understanding of the first and second laws of thermodynamics and their application to a wide range of systems
- Ability to understand and analyze the work and heat interactions associated with a prescribed process path, and to perform a first law analysis of a flow system
- Ability to evaluate entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.
- Familiarity with calculations of the efficiencies of heat engines and other engineering devices.
- An understanding of the interrelationship between thermodynamic functions and an ability to use such relationships to solve practical problems in power plants.

FINITE ELEMENT MODELING IN THERMAL ENGINEERING

L-T-P:3-0-0 Credit-3

Course Objectives:

The course should enable the students to:

- Equip the students with the Finite Element Analysis fundamentals,
- To formulate the design problems into FEA,
- Enable the students to perform engineering simulations using Finite Element Analysis software (ANSYS & LSDYNA).
- Understand the application of FEM to heat transfer and fluid flow problem.
- To understand the ethical issues related to the utilization of FEA in the industry

Course Contents

Module-I (8 Hours)

Fundamental Concept: Strain displacement relation, stress-strain relation, Plane stress, Plane strain problem minimization of total potential energy.

Module-II (12 Hours)

Concept of an Element; Displacement model, Shape functions for one Dimensional and two Dimensional problems, Constant strain Triangle. Iso parametric representation, Generalized co-ordinates, Element stiffness Matrix: Assembly procedure, Treatment of Boundary condition. Elimination approach, Penalty approach, some practical application.

Module-III (8Hours)

Solution of Linear Equations: Gauss Elimination Method, Gauss Seidelmethod. Convergence criteria.Scalar field problems: Variation formulation.

Module-IV (8 Hours)

Application to steady state heat transfer in one and two dimension, simple problem on fluid flow, steam function formulation.

Module-V (4 Hours)

Computer method and Computer programs, Automatic mesh generation, Data input, stiffness generation, solution of equations.

Text Books:

1. Abel and Desai: Introduction to finite element method (EWP Publications)

2.Chandrupatla and Belegundu; Introduction to finite elements in Engineering (PHI Publications)

Course Outcomes:

After successful completion of this course, the students will be able to:

- Identify mathematical model for solution of common engineering problems.
- Formulate simple problems into finite elements.
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.
- Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts

TURBULENCE MODELING L-T-P: 3-0-0 Credit 3

Course Objectives:

- To teach fundamentals of turbulent flows in fluid dynamics.
- To acquaint students with Statistical representation of turbulent flows
- To provide knowledge about Energy cascade and Kolmogorov hypothesis
- To study about Free shear and wall-bounded flows
- To give students an insight to solve real world turbulence modeling problems

Course Contents:

Module-1: Introduction: (7 Hours)
Origin of turbulence, irregularity, diffusivity, three-dimensional motions, dissipation, wide spectrum, length scales; Statistical Description of Turbulence: Probability density, moments, correlations, integral micro scales, homogeneous and isotropic turbulence, Kolmogorov hypothesis, energy cascade, turbulence spectra; Turbulent Transport: Reynolds decomposition, turbulent stresses, Reynolds equations, mixing-length model, dynamics of turbulence

Module-2: Statistical Description of Turbulence: (7 Hours)
Random nature of turbulence, distribution function, probability density, moments, correlations, Taylor's hypothesis, integral micro scales, homogeneous and isotropic turbulence, Kolmogorov hypothesis, scales of turbulence, energy cascade, turbulence spectra.

Module-3: Turbulent Transport of Moment and Heat: (6Hours)
Reynolds decomposition, turbulent stresses, vortex stretching, Reynolds equations, mixing-length model, Reynolds' analogy, dynamics of turbulence. Mixing Layer, Turbulent Wakes and Jets, Grid Turbulence.

Module-4: Wall-Bounded Turbulent Flows (5Hours)
Channel and pipe flows, Reynolds stresses, turbulent boundary layer equations, logarithmic-law of walls, turbulent structures.

Turbulence Modeling:
Introduction, eddy-viscosity hypothesis, algebraic model, k-ε and k-ω model, Reynolds-stress model, near-wall treatment, Introduction to LES and DNS.

Module-5: Experimental Methods (5Hours)
Introduction, hot wire anemometry, uncertainty analysis and laser doppler anemometry.

References:

1. Turbulent Flows, Stephen B. Pope, Cambridge University Press
2. A First Course in Turbulence, H. Tennekes and J. L. Lumley, MIT Press

Course Outcomes:

- Understand the basic principles of turbulence modeling
- Ability to understand the basic limitations of the most commonly used modeling approaches as well as to analyze turbulent flows using single-point descriptions
- Insight into basic turbulence physics and become a knowledgeable user of turbulence models
- Insight into advanced modeling approaches related to Large Eddy Simulations.
  Understand the use and limitations of Direct Numerical Simulations of turbulent flows.

GAS DYNAMICS AND JET PROPULSION

L-T-P:3-0-0 Credit-3

Course Objectives:

- To impart knowledge on concepts for the compressible flow of gases
- Study of conservation laws, normal and oblique shock waves and applications
- Study Quasi-One-dimensional Flow
- Study of Prandtl-Meyer flow and simple flows such as Fanno flow and Rayleigh flow with applications
- Study Shock Tube Relations

Course Contents:

MODULE 1: (10 Hours)

Fundamental Aspects of Gas Dynamics: Introduction, Definition of Compressible Flow, Flow Regimes, Internal Energy and Enthalpy, First and second laws of thermodynamics, Entropy Calculation, Isentropic Relations,Integral form of Conservation Equations for Inviscid Flow: Continuity Equation, Momentum Equation, Energy Equation

MODULE 2: (10 Hours)

One-Dimensional Flow: One-Dimensional Flow Equations, Speed of Sound and Mach Number, Alternative Forms of the One-Dimensional Energy Equation, Normal Shock Waves: Normal Shock Relations, Hugoniot Equation, One-Dimensional Flow with Heat Addition, One-Dimensional Flow with Friction.

MODULE 3: (7 Hours)

Oblique Shock Wave: Oblique's Shock Relations, Supersonic Flow over Wedge and Cones, Regular Reflection from a Solid Boundary, Pressure- Deflection Diagrams, Mach Reflection, Detached Shock Wave in Front of Blunt Body, Prandtl-Mayer Expansion Waves.

MODULE 4: (7 Hours)

Quasi-One-Dimensional Flow: Governing Equations, Area-Velocity Relation, Isentropic Flow of a Calorically Perfect Gas through Variable-Area Ducts, Diffusers, Wave Reflection from a Free Boundary.

MODULE 5: (6 Hours)

Unsteady Wave Motion: Moving Normal Shock wave, Reflected Shock Wave, Incident and Reflected Expansion Wave, Shock Tube Relations, Finite Compression Waves

Text Books:

1. John D. Anderson, Jr. Modern Compressible Flow. Second Edition, McGraw-Hill Publishing Company, 1990

Reference Books:

1. F. M. White, Viscous Fluid Flow. 2nd ed. New York: McGraw-Hill, 1991.
2. A.H. Shapiro, Compressible Fluid Flow 1 and 2. Hoboken NJ: John Wiley.
3. L. D. Landau and E. M. Lifshitz, Fluid Mechanics. 2nd ed., Butterworth-Heinemann, 1995.
4. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001.
5. P. H. Oosthuizen and W. E. Carscallen, Compressible Fluid Flow, NY, McGraw-Hill, 1997.

Course Outcomes:

1. Formulate and solve problems in one -dimensional steady compressible flow
2. Apply conservation laws to fluid flow problems
3. Gain knowledge about main properties which are used for analyzing or modelling of compressible flow.
4. Solve flow problems with heat addition and with friction.
5. Simulation of One-dimensional flow in Shock tube

ADVANCED I.C. ENGINE L-T-P:3-0-0 Credit-3

Course Objectives:

- To impart knowledge on SI and CI Engines and operating characteristics of modern internal combustion engines.
- Analysis of air standard cycles in the regard of I C Engine.
- Performance analysis of I C Engine.
- Be familiar with engine exhaust emission control.
- Understanding of induction system along with alternative fuel feed system

Course Contents:

MODULE – 1 (6 Hours)

Thermodynamics analysis of I C Engine cycles, Fuel-air cycles and actual cycles thermal efficiency and fuel consumption, Combustion in S.I engine and C.I engine, Use of combustion charts.Variable compression ratio engine; Theoretical analysis, method of obtaining variable compression ratio engine.

MODULE – 2 (8 Hours)

Super charging: Thermodynamic cycles with super charging, supercharging of S.I and C.I engines, effect of super charging on engine performance, limits of supercharging in C. I engines, method of super charging, superchargers. Stratified charge engines: Methods of charge stratification, stratification by fuel injection and positive ignition, swirl stratified charge engine, general characteristics of stratified charge engines.

MODULE – 3 (6 Hours)

Dual fuel and multi fuel engines: The working principle, combustion in dual fuel engines, super charge dual fuel engines, knock control in dual fuel systems, performance of dual fuel engines, characteristics of multi-fuel engine, performance of multi-fuel engines.

MODULE – 4 (5 Hours)

Engine Exhaust Emission Control: Formation of NOX, HC/CO mechanism, Smoke and Particulate emissions, Green House Effect, Methods of controlling emissions, Three way catalytic converter and Particulate Trap, Emission (HC,CO, NO and NOX) measuring equipments, Smoke and Particulate measurement, Indian Driving Cycles and emission norms.

MODULE – 5 (5 Hours)

Alternate Fuels: Alcohols, Vegetable oils and bio-diesel, Bio-gas, Natural Gas, Liquefied Petroleum Gas, Hydrogen, Properties, Suitability, Engine Modifications, Performance, Combustion and Emission Characteristics of SI and CI Engines using these alternate fuels.

Text books:

1. Internal Combustion Engines by Mathur and Sharma, Dhanpat Rai Publications.
2. Internal combustion engine fundamentals by J.B. Heywood, McGraw Hill Publications.

Course Outcomes:

- To illustrate design and performance of IC Engines throughthermodynamic cycles
- To analyze supercharging effect on SI and CI Engines and their performance
- Analyze fuel knocks and suggest controlling measures
- Recognize emission control norms in SI and CI engines and to reduce harmful emission
- Use alternate fuels in IC engines.

SOLAR ENGINEERING L-T-P:3-0-0 Credit-3

Course Objectives:

- To impart knowledge on the solar energies
- To impart knowledge different types of solar cooling and dehumidification systems
- To give students knowledge about thermal comfort and Bioclimatic conditions
- To Provide An Insight On Different Solar Refrigeration Systems
- To expose the students towards the current developments in solar technologies.

Course Contents:

MODULE 1: Solar passive heating and cooling(8 Hours)

Thermal comfort - Heat transmission in buildings - Bioclimatic classification. Passive heating concepts - Direct heat gain, indirect heat gain, isolated gain and sunspaces. Passive cooling concepts - Evaporative cooling, radiative cooling, application of wind, water and earth for cooling, roof cooling, earth air-tunnel. Energy efficient landscape design - Concept of solar temperature and its significance, calculation of instantaneous heat gain through building envelope.

MODULE 2: Solar liquid and air heating system(6 Hours)

Flat plate collector – Liquid and air heating - Evacuated tubular collectors - Overall heat loss coefficient, heat capacity effect - Thermal analysis. Design of solar water heating systems, with natural and pump circulation. Solar dryers and applications. Thermal energy storage systems.

MODULE 3: Solar cooling and dehumidification (8 Hours)

Solar thermo-mechanical refrigeration system – Carnot refrigeration cycle, solar electric compression air conditioning, simple Rankine cycle air conditioning system.

MODULE 4: Absorption refrigeration (4 Hours)

Thermodynamic analysis –Energy and mass balance of Lithium bromide-water absorption system, Aqua-ammonia absorption system, Calculations of HCOP and second law efficiency. Solar desiccant dehumidification.

Module 5: Solar thermal applications (4 Hours)

Solar systems for process heat production - Solar cooking – Performance and testing of solar cookers. Seawater desalination – Methods, solar still and performance calculations. Solar pond - Solar greenhouse.

Text Books:

1. Kalogirou S.A., "Solar Energy Engineering: Processes and Systems", Academic Press, 2009.
2. Goswami D.Y., Kreith F., Kreider J.F., "Principles of Solar Engineering", 2nd ed., Taylor and Francis, 2000, Indian reprint, 2003.

Reference books:

1. Duffie J. A, Beckman W. A., "Solar Engineering of Thermal Process", Wiley, 3rd ed. 2006.
2. Khartchenko N.V., "Green Power: Eco-Friendly Energy Engineering", Tech Books, Delhi, 2004.
3. Garg H.P., Prakash J., "Solar Energy Fundamentals and Applications", Tata McGraw-Hill, 2005.

Course Outcomes:

- Ability to recognize the need of solar energy sources for the present day energy crisis
- Employ solar energy technology in a given situation.
- To Be Able To Apply Solar Energy According To Thermal Comfort And Different Bioclimatic Conditions
- Develop and work on Various Solar Refrigeration Systems
- Work for the future development of solar energy technologies.

SESSIONALS

Thermo-fluids Lab-I

Numerical Simulation Lab

2nd Semester:

ADVANCED ENGINEERING THERMODYNAMICS

L-T-P: 3-0-0 Credit-3

Course Objectives

The course introduces advance concepts in thermodynamics.

- It is an extension to the introductory theory of energy analysis.
- Discussion on the entropy balance for closed system and open systems
- Strong emphasis on the concepts of availability and irreversibility
- To understand the properties of gas mixtures and criterion for equilibrium under various conditions.
- Strong emphasis on chemical equilibrium and application of first and second law on chemical reactions.

Course Contents

Module-I (7 Hours)

Recapitulations of fundamentals, Analysis of simple closed and open systems, Properties of Pure substance, first law of Thermodynamics applied to closed systems, first law applied to steady flow processes, Analysis of variable flow process.

Module-II (7 Hours)

Second law of Thermodynamics, Entropy: Entropy generation, Relationship between entropy generation and viscous dissipation, Entropy balance for closed and open systems.

Module-III (10 Hours)

Exergy: Concept of reversible work and Irreversibility, second law efficiency, Exergy change of a system: Closed and open systems, Exergy transfer by heat, work and mass, Irreversibility and GouyStodola theorem, Application of GouyStodola Theorem, Exergy destruction, Exergy balance in closed and open systems.

Module-IV (6)

Properties of gas mixtures: equation of state and properties of ideal gas mixtures, Change in entropy of mixing, Real gases, Generalized compressibility charts, General conditions for Thermodynamic equilibrium, Criterion for equilibrium under various conditions of isolation.

Module-V (10)

Chemical equilibrium: Concept of fugacity and activity, Thermodynamic of reactive systems, stoichiometry, Enthalpy of formation and Enthalpy of combustion, First and Second Law analysis of chemical reactions.

Text Books:

1. Fundamentals of Engineering Thermodynamics (7th Edition) by Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, Wiley Publication.
2. Fundamentals of Thermodynamics (6th Edition)by Richard E. Sonntag, Claus Borgnakke, Gordon J. Van Wylen, Wiley Publication

Course Outcomes:

After successful completion of this course, the students will be able to:

- Explain fundamental concepts relevant to thermodynamics.
- Answer the cause of entropy generation and establish relation between entropy generation and viscous dissipation.
- Determine how much of useful energy can be produced from a given thermal source.
- Explain the deviation of real gas from ideal gas and establish criterion for equilibrium under various conditions of isolation.
- Explain fundamental concepts relevant to chemical thermodynamics and apply first and second law to the analysis of chemical reactions.

CONVECTIVE HEAT AND MASS TRANSFER

L-T-P:3-0-0 Credit-3

Course Objectives:

- To introduce fundamental concepts and derivation of energy equation.
- To analyse Heat transfer for duct flow with various boundary conditions.
- To studyvarious turbulence models for heat transfer.
- To study convection with phase changes.
- To study mass transfer during convection.

Course Contents:

MODULE 1: **(8 Hours)**

Mass conservation, Momentum Equations, Derivation of Energy equation, Rules of scale analysis, Heat lines for visualizing Convection. Laminar Boundary layer Flow: Velocity and thermal boundary layers, Integral solutions, similarity solutions for uniform wall temperature and uniform wall heat flux, effect of longitudinal pressure gradient, effect of blowing and suction, Entropy generation minimization in laminar boundary layer flow.

MODULE 2: **(5 Hours)**

Heat transfer to fully developed duct flow: Uniform wall heat flux and Uniform wall temperature,Heat transfer to developing flow: Scale analysis, thermally developed uniform (slug) flow, thermally developing Hagen-Poiseuille flow,heat lines in fully developed duct flow.External natural convection: Laminar boundary layer equations, scale analysis: High and low-Pr fluids, Integral solutions: High and low-Prfluids, Similarity solution, Internal natural convection in a rectangular enclosure.

MODULE 3: **(8 Hours)**

Transition to turbulence: Empirical transition data, scaling laws of transition, buckling of inviscid streams, Instability of inviscid flow. Turbulent boundary layer flow: Large scale structure,boundary layer equations, mixing length model, heat transfer in boundary layer flow. Turbulent Duct flow: Heat transfer rate for isothermal wall and uniform wall heating.

MODULE 4: (5 Hours)

Convection with Phase Change:-Condensation:Laminar film on a vertical surface, Drop condensation; Boiling: Pool boiling Regimes, nucleate boiling and peak heat flux, film boiling and minimum heat flux, flow boiling; Contact melting and lubrication: plane surfaces with relative motion, melting by natural convection.

MODULE 5: (4 Hours)

Mass Transfer: Properties of mixtures, mass conservation, massdiffusivity, boundary conditions, Laminar forced convection, impermeable surface model, external and internal forced convection, Naturalconvection: mass transfer driven flow and heat transfer driven flow.

Text Book:

1. Convective heat transfer by A. Bejan (Willey)

Reference Books:

1. Convective heat transfer byS. Kakaç (CRC Press)

2. Convective heat transfer byLouis C. Burmeister

Course Outcomes:

On successful completion of the course, the student will be able to

1. Learn the details of energy equation and its application to various problems
2. Solve heat transfer problems involving duct flow
3. Apply various turbulence models for heat transfer problems
4. Deal with practical problems involving convection with phase changes
5. Solve heat transfer problems with mass transfer

CRYOGENIC TECHNOLOGY L-T-P: 3-0-0 Credit 3

Course Objectives:

- Imparting basic knowledge of low temperature generation
- To study about information concerning low temperature processes and techniques
- To give an overview of different gas separation and purification systems
- To learn about storage of cryogenic fluids along with equipments and instruments used
- Understanding various measurement systems for low temperature and their applications

Course Contents:

Module-1(10 Hours)

Introduction; Low temperature properties, Mechanical, Thermal, Electrical and Magnetic Properties of Cryogenic fluids.

Module-2 (10 Hours)

Gas liquefaction systems; Simple Linde – Hampson system, Pre-cooled Linde Hampson systems for Neon, Hydrogen and Helium; Collins liquefaction systems, Critical components of liquefaction systems, Components and its efficiencies on system performance.

Module-3 (10 Hours)

Gas separation and purification systems ; Properties of mixtures , Principle of gas separation i.e., Simple condensation and evaporation , Rectification, Air separation systems, Argon separation systems, Helium separation systems, Gas purification methods, Cryogenic refrigeration systems (Liquid and gas as refrigerant); Joule Thomson refrigeration systems, Cascade or pre-cooled Joule–Thomson refrigeration systems, Cold gas refrigeration system (solid as working media)

Module-4 (5 Hours)

Magnetic cooling, its thermodynamic aspects, Magnetic refrigeration system, thermal valves, nuclear demagnetization, Measurement system for low temperature; Cryogenic fluid storage and transfer systems, Thermal insulations for cryogenic applications in the order of increasing performance.

Module-5 (5 Hours)

Low temperature properties of engineering materials, superconductivity and superconducting devices, Special phenomenon at very low temperatures, Applications: Super conducting bearings, motors, Cryotrons, Chemical rockets, Space Simulation, Nuclear rockets , Blood and tissue preservation.

Text Books:

1. Barron, R., Cryogenic Systems, SI version, Oxford university press, 1985
2. Scott, R. B., Cryogenic Engineering, D'Van- Nostrand, 1962.

Reference Books:

1. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
2. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
3. Marshall Sittig, Cryogenics Research and Applications, D. Van Nostrand Company, 1963
4. B.A.Hands, Cryogenic engineering, Academic press, 1986 7.Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker Inc., New York, 2005.

Course Outcomes:

- Ability to grasp low temperature properties of cryogenic fluids
- To gain an understanding of working principles of different cryogenic refrigeration and liquefaction systems
- Assimilation of different methods of separation and purification of cryogenic fluids and identify effects of various components on system performance
- Accessing the real-time difficulties and hazards in storing cryogenic liquids and understanding cryogenic insulations for increase in performance
- Learn to select and use engineering materials for different cryogenic applications.

THERMAL SYSTEM SIMULATION AND DESIGN L-T-P: 3-0-0 Credit 3

Course Objectives:

1. To understand various definitions and theoretical concepts related to Thermal energy systems
2. To impart knowledge on thermal system simulation and modelling for design
3. To study the problem formulation for optimization of thermal system
4. To understand the various Optimization technique for unconstrained problems
5. To understand optimization methods such as integer programming

Course Contents:

MODULE 1: (8 Hours)

Formulation of the design problem: design variables, constraints and limitations,requirements and specifications; Conceptual design, Steps in the design process (examples from thermal systems), Material selection.

MODULE 2: (10 Hours)

Modeling of thermal systems: types of models, mathematical modeling, physical modeling and dimensional analysis, curve fitting. Acceptable design of a thermal system: initial design, design strategies, some application illustrations (cooling of electronic equipment, heat transfer equipment, fluid flow systems etc.).

MODULE 3: (8 Hours)

Problem formulation for optimization: optimization in design, final optimized design, objective function, constraints, operating conditions, types of thermal systems, practical aspects in optimal design (choice of variables for optimization, sensitivity analysis, dependence on objective function and change of concept or model), Knowledge-based design and additional considerations, professional ethics.

MODULE 4: (7 Hours)

Optimization of unconstrained problems, optimization of constrained problems, applicability to thermal systems, search methods (single variable problem, unconstrained search with multiple variables and multivariable constrained optimization).

MODULE 5: (7 Hours)

Integer programming - penalty function method. Use of artificial intelligence techniques (neural network, fuzzy logic and genetic algorithm) in thermal systems design and optimization (simple examples).

Text Books:

1. Y. Jaluria, Design and Optimization of Thermal Systems, CRC Press, 2007.
2. S. S. Rao, Optimization methods, PHI, 1998

Reference Books:

1. W.F. Stoecker, Design of Thermal Systems - McGraw-Hill, 1971.
2. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization - Wiley, 1996.
3. R. F. Boehm, Developments in the Design of Thermal Systems - Cambridge University

Course Outcomes:

- Develop knowledge on theoretical concepts related to thermal systems design
- Ability to simulate and model thermal system
- Implement various optimization methods for thermal system design
- Implement various Optimization technique for unconstrained problems
- Implement integer programming methods for thermal system

COMPUTATIONAL FLUID DYNAMICS L-T-P: 3-0-0 Credit 3

Course Objectives:

- To develop an understanding for various methodologies used in CFD
- To understand the skills required in the actual implementation of CFD methods
- To learn Finite difference discretization methods for solving fluid flow problems
- To learn Finite Volume discretization methods for solving fluid flow problems
- To learn various Solution methods for solving simultaneous Equations

Course Contents:

MODULE 1: (7 Hours)

Introduction: Partial Differential Equations, Mathematical Classification, Systems of Partial Differential Equations,

MODULE 2: (10 Hours)

Finite Difference Discretization Methods: Various aspect of Finite Difference Methods, Truncation Error, Round-Off and Discretization Errors, Consistency, Stability, Convergence for Marching Problems, Conservation Form and Conservative Property, Methods for obtaining Finite Difference Equations, Use of Taylor Series, Integral Method

MODULE 3: (8 Hours)

Finite Volume Discretization Methods: Various aspect of Finite Volume Methods, Use of Irregular Meshes, Irregular Mesh due to Shape of a Boundary, Irregular Mesh Not Caused by Shape of a Boundary, Fourier or von Neumann Analysis, Stability Analysis for Systems of Equations. Solution of conduction and Convection-Diffusion Problems

MODULE 4: (8 Hours)

Numerical Methods for Model Equations: Wave Equation:Upstream (First-Order and Second Order Upwind or Windward) DifferencingMethod,Lax Method,Lax–Wendroff Method, Mac Cormack Method, Runge–Kutta Methods, Heat Equation:Richardson's Method, Crank–Nicolson Method, Burgers' Equation (Inviscid and Viscous):Godunov Scheme, Roe Scheme, FTCS Method, Allen–Cheng Method

MODULE 5: (7 Hours)

Solution of Simultaneous Equations: Direct Methods:Cramer's Rule,Gaussian Elimination,Thomas Algorithm, Advanced Direct Methods, Iterative Methods:Gauss–Seidel Iteration, Successive Overrelaxation, SOR by Lines, ADI Methods, Krylov Subspace Methods

Course Outcomes:

- Understand and be able to classify the governing equations for fluid flow
- Understand and apply finite difference and finite volume methods to fluid flow problems
- Solve Model Equations of Fluid Flow and Heat Transfer using various numerical schemes
- Assess stability criteria and conduct a grid-convergence test
- Able to numerical solve and implement code for Simultaneous Equations

Text Books:

1. Tannehill, J.C., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and HeatTransfer, 3rded., Taylor & Francis, 2013.

Reference Books:

1. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000
2. Peyret, R. and Taylor, T. D., Computational Methods for Fluid Flow, Springer-Verlag, 1983.

INTRODUCTION TO TWO PHASE FLOW L-T-P: 3-0-0 Credit 3

Course Objectives:

- To understand different flow patterns in two phase flow.
- To understand flow mappings and its significance in two phase flow
- To learn different analytical models for two-phase flows
- To learn different measurement techniques
- To describe the hydrodynamics of gas-solid flow

Course Contents:

Module – I (8 Hours)

Introduction to two phase flow, applications, methods of analysis, different terminologies, flow regimes in vertical and horizontal flow, flow regime mappings.

Module– II (10 Hours)

Homogenous flow: One-dimensional steady homogenous equilibrium flow, conservative equations, pressure drop, homogenous friction factor for laminar and turbulent flow , pressure drop in bends, tees, orifices and valves. Homogenous theory extended to unsteady flow

Module– III (10 Hours)

Separated flow: Introduction, steady homogenous flow with different velocities, condition for choking, evaluation of wall shear stress and void fraction, empirical correlations, Governing equations for separated flow, Comparison with homogenous model

Module– IV (6 Hours)

Measurement techniques for two phase flow: Flow regime identification, pressure drop, void fraction and flow rate measurement.

Module– V (6 Hours)

Hydrodynamics of gas-solid flows, suspension of particles in fluids, particulate fluidization, fluidized bed

Text Book:

1. One dimensional two phase flows by Graham B Wallis, McGraw Hill, 1969.

2. Two-Phase Flow: Theory and Applications by Cl Kleinstreuer, CRC Press.

3. Two-phase flow and heat transfer by P. B. Whalley, Oxford University Press, USA.

Course Outcomes:

On successful completion of the course, students will be able to:

- Understand flow patterns and flow mapping.
- Perform mathematical modelling for two phase flows
- Predict pressure drop for a homogenous flow
- Predict void fraction and pressure drop in two phase flow experiments
- Understand the hydrodynamics of particulate flow in fluids

AIR-CONDITIONING ENGINEERING L-T-P: 3-0-0 Credit 3

Course Objectives:

- To give an overview about Psychometric concepts and air-conditioning systems.
- Impart knowledge on various types of Air-conditioning systems
- To study in details about various types of heat loads and heat gain through solar radiation
- To know about air distribution systems
- To study about piping and efficient duct design

Course Contents:

Module-I (10 Hours)

Psychometry: Definition, Psychometric terms, Degree of saturation, Humidity, Absolute Humidity, Relative humidity, dry bulb temperature, wet bulb temperature, wet bulb depression, Dew point temperature, Dew point depression, Dalton’s law of Partial pressure, Psychometric Relations, Humidity ratio, Psychometer, Psychometric chart, Psychometric Processes, Sensible heating, Sensible cooling, By-pass factor of heating and cooling coils, Dehumidification and humidification , Methods of humidification and dehumidification.

Module-II (08 Hours)

Air-conditioning systems: Introduction, Air conditioning system and equipments used in air-conditioning system, Various types of air-conditioning systems, Comfort Air-conditioning, Factors affecting effective optimum temperature, Factors affecting comfort air-conditioning, Room Sensible heat factor and Grand sensible heat factor.

Module-III (08 Hours)

Cooling Load estimation: Air-conditioning calculations, Comfort scales and measures concepts of effective temperatures, Solar heat gains through gains through glass, buildings, heat storage, diversity and stratification, Internal heat gains: Sensible heat, Latent heat.

Module- IV (07 Hours)

Cooling towers, spray chambers, Cooling and humidifying coils, Design of air-duct system, Room air distribution principles, Temperature, pressure and humidity controls, Various types of system controls, Building automation systems.

Module-V (07 Hours)

Ducts: Introduction, Classification, Material of duct, construction, shape, pressure in ducts, Continuity equation and Bernoulli's equation for ducts, Pressure losses inducts: Frictional losses & Dynamic losses, Duct design, pressure loss due to enlargement in area and static regain

Textbooks:

1. C. P. Arora, Ref & Air Conditioning (TMH Publication)

2. A text book of Refrigeration and Air-conditioning by R.S. Khurmi and J.K. Jai, S.Chand & Co.

Reference Books:

3. Stoecker and Zones: Refrigeration and Air Conditioning (Mc Graw Hill)
4. Manohar Prasad: Refrigeration and Air Conditioning (EWP)
5. W.P. Zones: Air Conditioning Engg. (Edward Arnold Press)

Course Outcomes:

- Ability to apply thermodynamic principles by study of various refrigeration cycles and evaluating performance using Mollier charts and refrigerant property tables
- Design of air-conditioning systems and develop understanding of the principles and practice of thermal comfort by doing cooling load estimation for air conditioning systems used for various applications
- To demonstrate an ability to analyse and develop techniques for building envelope loads
- Show an ability to apply the HVAC theory to design a HVAC system
- Analyze and design fan and duct systems

MICROFLUIDICS L-T-P: 3-0-0 Credit 3

Course Objectives:

1. To introduce the basic principles of micro-scale fluidic mechanics
2. To learn fluid mechanics principles in microchannels
3. To learn about capillary flows
4. To learn Electro hydrodynamics fundamentals
5. To review applications of microfluidics in various emerging fields.

MODULE 1: (5 Hours)

Introduction: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

MODULE 2: (15 Hours)

Micro-scale fluid mechanics: Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere,

MODULE 3: (07 Hours)

Capillary flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

MODULE 4: (10 Hours)

Electrokinetics: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electroosmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis,

MODULE 5: (03 Hours)

Few applications of microfluidics: Drug delivery, Diagnostics, Bio-sensing.

Text Books:

6. Fundamentals and applications of Microfluidics, by Nguyen and Werely, Artech house Inc., 2002.
7. Introduction to microfluidics by Tabeling, Oxford University Press Inc., 2005.

Course Outcomes:

On successful completion of the course, students will be able to:

- Understand the physics of fluid flow in microchannels
- Understand the surface force dominating in the microscale
- Solve simple problems of gas and liquid flows in microchannels
- Perform electrokinetic analysis of microchannel flows
- Understand the drug delivery system and bio-sensing.

SESSIONALS

Minor project & Seminar

Thermo-fluids Lab-II

Research Seminar

3rd Semester:

EXPERIMENTAL TECHNIQUES FOR THERMAL ENGINEERING

L-T-P: 3-0-0 CREDIT: 3

Course Objectives:

- Impart knowledge on basic concepts of measurement techniques.
- Learn methods of measuring physical quantities
- Study Measurement of temperature, pressure, velocity and flow rate.
- Gain knowledge about measurement of concentration & humidity of thermal systems.
- Understand the use of electrical, electronic and digital means of measurement

Course Contents:

Module-I (10 Hours)

Measurement: Introduction, Basic concepts of measurement methods, single and multi-point measurement in space and time, Processing of experimental data, Process of Measurement, Methods of measurement, Primary, Secondary & Tertiary Measurement, Types of measuring instruments, Scale Range & Scale span, Static Calibration, Error Calibration Curve, Static & Dynamic characteristics of measurement, Accuracy, Sensitivity, Reproducibility, Repeatability, Drift, Static error, Dead zone, Error analysis and estimation, Types of errors, Random error, Systematic error, True value, Absolute error, Relative static error, Error analysis and numerical.

Module-II (10 Hours)

Statistical error analysis: Curve fitting, Regression analysis, Analog and Digital instruments, Noise, Signal to Noise ratio, various sources of Noise, Numericals related to errors and noise

Measurement of temperature: Thermocouple, analysis of effect of bead size and shielding on time constant and frequency response characteristics of thermocouples, Errors due to conduction and radiation in well type thermocouple, thermocouple installations, resistance and resonant quartz thermometer, Pyrometry, Low temperature measurement, Measurement of heat flux and thermal conductivity.

Module-III (8 Hours)

Measurement of pressure: Measurement of pressure, Very low pressure measurement, Pirani gauge, McLeod Gauge, and other gauges

Measurement of flow rate and velocity: Measurement of Incompressible flow: Venturi-meter, Nozzle, Orifice-meter, Measurement of Compressible flow: Principle and theory of Pitot tube, Rotameter

Module-IV (4 Hours)

Principle and theory of measurement of concentration & humidity: Hygrometers, Chromatography, Calorimetry

Module-V (8 Hours)

Advanced Measurement techniques and analysis Non-intrustive measurement, Hot-wire anemometer, gas chromatography, Shadograph, Schliren Technique, Interferometer, Spectrometry

Textbooks:

1. J.P.Holman, Mechanical Measurements (Mc Graw Hill – 1989)
2. Mechanical Measurement by R.S. Sirohi, S.C. Radhakrishna (Wiley,1993)
3. Mechanical Measurements and Instrumentation by R.K.Rajput (S.K.Kataria & Sons, 2009)

Reference Books:

1. E.O. Doeblin, Mechanical Measurements (Int. Edition, 1983)
2. Doeblin, Measurement System Application and Design, McGraw-Hill, 1978
3. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and 2 MIR Publishers, 1980
4. Morris, A. S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.

Course Outcomes:

- Ability to understand the general concepts and terminology of measurement systems in engineering.
- Perform Error analysis, estimation of Noise to signal ratio and calibration of measuring instruments
- Acknowledge, access and analyse various experimental techniques.
- Carry out uncertainty analysis while designing various thermal systems
- Gain knowledge about advanced Measurement techniques, planning and selection of measuring instruments.

COMPUTATIONAL GAS DYNAMICS L-T-P: 3-0-0 Credit 3

Course Objectives:

- To learn conservation form of Euler equations of gas dynamics.
- To study scalar conservation laws
- To learn Riemann Problem
- To learn conservative finite volume methods
- To learn basic numerical methods for conservation laws

Course Outcomes:

Module – I (8 Hours)
Governing Equation of Gas Dynamics: Integral form of Euler equations, The Conservation form of Euler equations, Primitive variable form of Euler equations, Other form of Euler equations.

Module– II (8 Hours)
Scalar Conservation Laws: Integral Form, Conservation Form, Characteristic Form, Expansion Waves, Compression Waves and Shock Waves, Contact Discontinuity, Linear Advection Equation, Burgers' Equation, Non-Convex Scalar Conservation Laws, Entropy Condition, Waveform Preservation, Destruction and Creation

Module– III (8 Hours)

The Riemann Problem: Riemann problems for Euler equations and Linear systems of equations, Roe's Approximate Riemann solver for Euler equations. One wave Linear Approximation, Other Approximate Riemann solvers, Riemann problems for Scalar Conservation Law.

Module– IV (10 Hours)
Computational Gas Dynamics: Conservative finite volume methods, Conservative finite difference methods, Transformation to conservation form, The CFL Condition, Upwind and Adaptive Stencils, Introduction to Flux Averaging, Introduction to Flux Splitting, Flux Split Form, Introduction Flux reconstructions. Artificial Viscosity, Total Variation Diminishing(TVD), Essentially Nonoscillatory (ENO).

Module– V (6 Hours)
Basic Numerical Methods for Scalar Conservation Laws: Lax-Friedrichs Methods, Lax-Wendroff Methods, First-Order Upwind Method, Beam-Warming Second-Order Upwind Methods, Boundary Treatments, Solid Boundaries and Far-Field Boundaries.

Text Book:

8. Culbert B. Laney. Computational Gasdynamics (2007). Cambridge University Press.
9. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997). Computational Fluid Mechanics and Heat Transfer. Taylor & Francis.

Course Outcomes:

- On successful completion of the course, students will be able to:
- 1. Ability to understand conservation form of Euler equations of gas dynamics.
- 2. Understand scalar conservation laws
- 3. Solve Riemann Problem using various scheme
- 4. Understand and implement conservative finite volume methods for solving Euler equations
- 5. Implement various numerical methods for conservation laws

GAS TURBINE AND JET PROPULSION

L-T-P:3-0-0 Credit-3

Course Objectives:

The course should enable the students to:

- Utilize the fundamental principles of fluid mechanics and thermodynamics to analyze aircraft engines.
- Understand the common gas turbine aircraft propulsion systems and be able to determine the applicability of each.
- Be able to perform system studies of aircraft engine systems for specified cruise conditions at the preliminary design level.
- Be able to perform preliminary aero thermal design of turbo machinery components.
- Be able to analyze and perform preliminary design of terrestrial gas turbine systems, including alternative cycles.

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Course Contents:

Module-I (7 Hours)

Gas Dynamics Of Passive Components Of Turbo-engine fundamentals Of Gas Dynamics: Energy equation for a non-flow process, Energy equation for a flow process, The adiabatic energy equation, Momentum Equation, Moment of Momentum equation, Stagnation Velocity of Sound, Stagnation Pressure, Stagnation Density, Stagnation State, Velocity of sound - Critical states – Mach number - Critical Mach number - Various regions of flow.

Module-II (8 Hours)

Analysis Of Diffusers And Nozzles: Introduction -study of intakes for subsonic and supersonic engines, Comparison of isentropic and adiabatic processes, Mach number variation, Area ratio as function of Mach numbers, Mass flow rates, Flow through nozzles, Flow through diffusers, Effect of friction, Analysis of intakes for supersonic engines, Intakes with normal shock, Oblique shocks.

Module-III (7 Hours)

Study Of Compressors: Design and Analysis of compressors - Classification -analysis of centrifugal compressors - velocity triangles. Analysis of axial flow compressor, analysis of stage, characterization of stage. Design of multistage axial flow compressor.

Module-IV (6 Hours)

Study Of Turbines: Concept of gas turbine - analysis of turbine stage – velocity triangles and characterization of blades and stages.

Module-V (12 Hours)

Propulsion: Aircraft Propulsion - introduction - Early aircraft engines -Types of aircraft engines - Reciprocating internal combustion engines - Gas turbine engines - Turbo jet engine - Turbo fan engine - Turbo-prop engine. Aircraft propulsion theory: thrust, thrust power, propulsive and overall efficiencies.

Thermodynamic Analysis Of Ideal Propulsion cycles: Thermodynamic analysis of turbojet engine - Study of subsonic and supersonic engine models - Identification and Selection of optimal operational parameters. Need for further development - Analysis of Turbojet with after burner. Thermodynamic analysis of turbofan engine - Study of subsonic and supersonic systems - Identification and selection of optimal operational parameters. Design of fuel efficient engines - Mixed flow turbo fan engine - Analysis of Turbofan with after burner.

Text Books:

1. Gas turbine theory by V VGanesan
2. Gas turbines and propulsive systems by P.R.Khajuria and S.P.Dubey
3. Fundamentals of compressible fluid flow by S.M.Yahya

Course Outcomes:

After successful completion of this course, the students will be able to:

- A basic understanding of thermodynamic cycles of jet engines.
- A basic understanding of the compressible fluid flow in inlets andcompressors and turbines.
- A basic understanding of the combustion physics in combustion chambers.
- A basic understanding of the rationale behind several types of jet engines.
- The ability to analyze jet engines; determine propulsion efficiency anddesign inlets and nozzles.

NON-CONVENTIONAL ENERGY

L-T-P: 3-0-0 Credit-3

Course Objectives:

The course should enable the students to:
1. Understand the various forms of conventional energy resources.
2. Learn the present energy scenario and the need for energy conservation
3. Explain the concept of various forms of renewable energy
4. Outline division aspects and utilization of renewable energy sources for both domestics and industrial application
5. Analyse the environmental aspects of renewable energy resources.

Course Contents:

Module-I (8 Hours)

Introduction to energy sources: Renewable and non-renewable energy sources, energy consumption as a measure of Nation's development; strategy for meeting the future energy requirements, Global and National scenarios, Prospects of renewable energy sources.

Solar Energy: Solar radiation- beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar times, derived solar angles, sunrise, sunset and day length. Flat plate collectors, concentrating collectors, solar air heater-types, solar driers, storage solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating and cooling of buildings, photovoltaic-solar cells and its applications.

Module-II (8 Hours)

Wind Energy: Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components; various types and their constructional features; design considerations of horizontal and vertical axis wind machines; analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations.

Energy from Biomass: Biomass conversion technologies; Biogas generation plants: Classification, advantages and disadvantages, constructional details site selection, digester design consideration, filling a digester for starting, maintaining biogas production, fuel properties of biogas, utilization of biogas.

Module-III (8 Hours)

Geothermal Energy: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.

Energy from the Ocean: Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India, Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitations and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy.

Module-IV (8 Hours)

Magneto Hydro Dynamic (MHD) Power generation: Principle of MHD power generation, MHD system, Design problems and developments, gas conductivity, materials for MHD generators and future prospects.

Fuel Cells: Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells.

Module-V (8 Hours)

Hydrogen Energy: Introduction, Hydrogen production methods, hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles.

Energy management: Energy economics, energy conservation, energy audit, general concept of total energy system, scope of alternative energy system in India.

Course Outcomes:

Upon completion of the course, the student will be able to:

- Describe the environmental aspects of non-conventional energy resources. In Comparison with various conventional energy systems, their prospects and limitations.
- Know the need of renewable energy resources, historical and latest developments.
- Describe the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, power generation, drying, cooking etc.
- Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.
- Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications

MATRIX COMPUTATIONS L-T-P: 3-0-0 Credit-3

Course Objectives:

- To learn the algorithms underlying matrix computations
- To learn solution of linear systems
- To learn least squares problem and singular value decomposition
- Understand basic of QR algorithms
- Understand the difference between iterative methods for linear systems and direct methods

Course contents:

Module - I: Gaussian Elimination and Its Variants (10Hours)
Overview of matrix computations, Matrix Multiplication, Systems of Linear Equations, Triangular Systems, Positive Definite Systems; Cholesky Decomposition, Banded Positive Definite Systems, Sparse Positive Definite Systems, Gaussian Elimination and the LU Decomposition

Module - II: Solution of Linear Systems (8Hours)
Vector and Matrix Norms, Condition Numbers, Perturbing the Coefficient Matrix, A Posterior Error Analysis Using the Residual, Round off Errors; Backward Stability, Component wise Sensitivity Analysis

Module - III: Solution of Least Squares of Problem (7Hours)

The Discrete Least Squares Problem, Orthogonal Matrices, Rotators, and Reflectors, Solution of the Least Squares Problem
Module - Iv: The Singular Value Decomposition (7Hours)
Some Basic Applications of Singular Values, The SVD and the Least Squares Problem

Module - IV: Solution of Eigen-value Problem (4Hours)

Systems of Differential Equations, Basic Facts, The Power Method and Some Simple Extensions, The QR Algorithm, Implementation of the QR algorithm, Use of the QR Algorithm to Calculate Eigenvectors

Module - V: Iterative Methods for Solution of Linear Systems (4Hours)
Overview of iterative methods, Jacobi, Gauss-Seidel and successive over relaxation methods, Pre-conditioners, The Conjugate-Gradient Method

Course Outcomes:

- Understand the algorithms underlying matrix computations
- Solve solution of linear systems
- Solve least squares problem and singular value decomposition
- Implement QR algorithms
- Understand the difference between iterative methods for linear systems and direct methods

Text Books:
1. D. S. Watkins, Fundamentals of Matrix Computations, 2nd. ed., Wiley Interscience, 2002.

Reference Books:
1. J. W. Demmel, Applied Numerical Linear Algebra, SIAM, 1997
2. G. H. Golub and C. F. Van Loan, Matrix Computations, 3rd Edition, John Hopkins University Press, 1996
3. L. N. Trefethen and D. Bau III, Numerical Linear Algebra, SIAM, 1997

SMART MATERIALS L-T-P: 3-0-0 Credit 3

Course Objectives:
- Impart knowledge on different types of materials and throw light on novel materials
- To study about fundamentals of fabrication processes for polymer matrix, metal matrix, and ceramic matrix composites.
- To study about elastic and hygrothermal properties of long fiber and short fiber composites.
- Analysis of thermal aging, fatigue and failure of materials.
- To get an insight on applications of Smart materials in Optical fibers, actuators and sensors

Course Outcomes:

Module-I (10 Hours)
Introduction: Types of materials, Composites: Introduction to composites and their classification, Types of fibers, Particulate composites, Hybrid composites, Long aligned fiber composites, properties, application and morphology of fibre reinforced composites, metal matrix composites and ceramic composites.
Reinforcements: Glass fibers, Boron fibers, Carbon fibers, Organic fibers, Ceramic fibers, Non-oxide fibers, Comparison of different types of fibers.

Matrix Materials: Polymers, metals, Ceramic matrix materials and their properties

Module -II (8 Hours)
Processing of Composites: Hand lay-up, Pre-peg processing, Press-molding, Vacuum molding, Filament winding, extrusion, Pultrusion, liquid metal infiltration process, Diffusion

bonding and powder metallurgy methods, joining of composites, Basic properties of GRP, CFRP, Al-B, Casting and Particulate composites.
Interfaces: Wettability, Crystallographic nature of interface, Interactions at the interface, Types of bonding at the interface, Test for measuring interfacial strength.

Module-III (8 Hours)
Properties and Applications: Modulus, Strength, Thermal characteristics, Aging, Fatigue, Creep, Transport properties, Matrix connectivity, Aerospace application, Structural, Defense biomedical application, Machine tools, Automobiles applications, finite element method for simulation and optimization.
Failure/ Fracture of Composites: Tensile strength, Compressive strength, Fractures modes in composites.

Module-IV (7 Hours)
Smart materials: Introduction to smart materials, Structure, characteristics and application of polymers, Structure, properties and applications of thermosetting (epoxy resin and akelite) and thermoplastics (polyvinyl chloride and polytetrafluoroethylene), Compounding of plastics injection and extrusion moulding. sensor applications based on required properties optical fibers, actuators, and methods of analyses employed in smart materials.

Module-V (7 Hours)
Need of materials characterization and available techniques:
Optical Microscopy: Optical microscope - Basic principles & components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Specimen preparation, Applications.

Electron Microscopy: Interaction of electrons with solids, scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.

Diffraction Methods: Fundamentals of crystallography, X-ray diffraction techniques, Electron diffraction, Neutron diffraction. Surface Analysis: Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy. Spectroscopy: Atomic absorption spectroscopies, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy.

Thermal Analysis: Thermogravimetric analysis, Differential thermal analysis, Differential Scanning calorimetry, Experimental methods for characterization of composite materials

Course Outcomes:
- Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites.
- Asses the applicability of a composite material for selection of a specific application by modeling, simulating and optimizing the performance of composites as well as developing practical skills in one or more common manufacturing and be able to select the appropriate technique for manufacture of fibre-reinforced composite products.
- Analyse the elastic properties ,simulate the mechanical performance and understand and predict the failure behaviour of fibre-reinforced composites
- Comprehend the principles of operation of optical fibers, actuators, and methods of analyses employed in smart materials
- Gain knowledge about Mechanical and thermal characterization of Smart materials and for different applications.

Text Books:

1. Gandhi M V and Thompson B S, Smart Materials and Structures, Chapman & Hall, Madras, 1992. 2. Meirovitch L., Dynamics and Control of Structures, John Wiley, 1992.
2. Smallman, R.E., and Bishop, R.J., Metals and Materials – Science, Processes, Applications, Butterworth-Heinemann (1995).
3. Sibilia J.P., A Guide to Materials Characterisation and Chemical Analysis, VCH (1988).

Reference Books:

1. Gabriel, B. SEM- A Users's Manual, Plenum Press (1985).
2. Cullity, B.D. Elements of X-Ray Diffraction, Addison Wesley (1967).

SESSIONALS

Dissertation (Phase-I)

4th Semester:

SESSIONALS

Dissertation (Phase-II)