Master of Technology

in

Mechanical Engineering

(Computational Thermal Engineering)

Course Structure & Syllabus

Department of Mechanical Engineering

National Institute of Technology Hamirpur

Hamirpur (HP) – 177005, India

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

Semester-I

S. No.	Course No.	Course Name	Teaching Schedule			Hours/Week	Credit
			L	T	P		
1.	ME-611	Advanced Thermodynamics and Combustion	4	0	0	4	4
2.	ME-612	Computational Methods in Thermal Engineering	4	0	0	4	4
3.	ME-613	Advanced Fluid Mechanics	4	0	0	4	4
4.	ME-614	Thermal Engineering Lab	0	0	4	4	2
5.	ME-7MN	Program Elective – I	4	0	0	4	4
6.	ME-7MN	Program Elective – II	4	0	0	4	4
Total			**20**	**0**	**4**	**24**	**22**

Semester-II

S. No.	Course No.	Course Name	Teaching Schedule			Hours/Week	Credit
			L	T	P		
1.	ME-621	Computational Fluid Dynamics	4	0	0	4	4
2.	ME-622	Convective Heat Transfer	4	0	0	4	4
3.	ME-623	Compressible Flows	4	0	0	4	4
4.	ME-624	Computational Lab	0	0	4	4	2
5.	ME-7MN	Program Elective-III	4	0	0	4	4
6.	ME-70N	Institute Elective (Interdisciplinary)	4	0	0	4	4
Total			**20**	**0**	**4**	**24**	**22**

Semester-III

S. No.	Course No.	Course Name	Hours/Week	Credit
1.	ME-798	M. Tech. Dissertation	……..	18
Total			……..	**18**

Semester-IV

S. No.	**Course No.**	**Course Name**	Hours/Week	Credits
1.	ME-799	M. Tech. Dissertation	……..	18
Total			……..	**18**

Annexure

(A) List of Program Elective Courses

S. No.	Course No.	Program Elective – I
1.	ME-711	Turbomachines Design
2.	ME-712	Design and Analysis of Experiments
3.	ME-713	Design of Refrigeration Systems
4.	ME-714	Design of Heat Exchangers
5.	ME-715	Design of Thermal Systems

S. No.	Course No.	Program Elective – II
1.	ME-721	Gas Turbines and Jet Propulsion
2.	ME-722	Solar Energy Technologies
3.	ME-723	Energy Conservation and Waste Heat Recovery
4.	ME-724	Hydrogen Energy
5.	ME-725	Cryogenics Engineering
6.	ME-726	Heating, Ventilation and Air Conditioning

S. No.	Course No.	Program Elective – III
1.	ME-731	Multiphase Flows
2.	ME-732	Micro Fluidics
3.	ME-733	Turbulent Flows
4.	ME-734	Fluid and Heat Transport through Porous Media
5.	ME-735	Micro and Nano Scale Heat Transfer

(B) List of Institute Elective Courses

S. No.	Course No.	Institute Elective (Interdisciplinary)
1.	ME-701	Thermal Managements of Electronic Systems
2.	ME-702	Measurement and Data Acquisition System
3.	ME-703	Optimization Methods in Engineering
4.	ME-704	Soft Computing Methods in Engineering
5.	ME-705	Fault Diagnosis and Signal Processing
6.	ME-706	Introduction to Design of Experiments
7.	ME-707	Logistics and Supply Chain Management

Advanced Thermodynamics and Combustion

Course Code: ME-611 Course Type: Core

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart knowledge about the concept of basic thermodynamic systems.
- To impart knowledge of real gas behavior and introduction to exergy and statistical thermodynamics.
- To impart knowledge on different thermodynamic property relations and their applications.

Course Content

Laws of Thermodynamics, Concept of entropy and entropy generation, Concept of exergy & irreversibility, Exergy analyses of open and closed system, Second Law efficiency, Exergy analysis for power and refrigerating cycles, Maxwell relations, Relations involving enthalpy, internal energy and entropy, Mayer relation, Clausius-Clapeyron equation, Joule-Thompson experiment, Multi-component and multi-phase systems, Equations of states and properties of ideal and real gas mixtures, Change in entropy in mixing, Finite time thermodynamic principle, Optimization of various thermodynamic systems, Principles of entropy generation minimization, Combustion and thermochemistry, Reactant and product mixtures, Adiabatic flame temperature, Chemical equilibrium, Equilibrium products of combustion, Chemical potential fugacity and fugacity coefficient, Chemical Kinetics, Types of flames, Simplified analyses of premixed & diffusion flames, Factors influencing flame velocity and thickness, Quenching, flammability and ignition, Flame stabilization, Pressure and energy equations using kinetic theory, RMS velocity, Equi-partition of energy, Mean free path, Maxwell distribution function

Course Outcomes

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

CO1: Apply the concepts of entropy and exergy analysis for analyzing industrial and domestic applications.

CO2: Estimate the properties of pure substance and thermodynamic properties of real gases.

CO3: Apply energy balances to reacting systems for both closed and open systems.

Books and References

1. Advanced Engineering Thermodynamics by A. Bejan, John Wiley and Sons, 2016
2. Advanced Thermodynamics for Engineers by K. Wark, McGraw Hill, 1994
3. Fundamentals of Thermodynamics by R.E. Sonntag, C. Borgnakke and G.J. Van Wylen, Wiley, 10th Edition, 2019

Computational Methods in Thermal Engineering

Course Code: 612 | Course Type: Core

Contact Hours/Week: 4L | Course Credit: 4

Course Objectives

- Acquire working knowledge of computational complexity, accuracy, stability, and errors in solution procedures.
- To understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
- To apply the numerical methods to solve thermal engineering problems.

Course Content

Application of CFD in Engineering, Numerical Method, Jacobi- iteration method, Gauss Siedel iteration method, classification of quasi-linear partial differential equations, methods of determining the classification, General behaviour of Hyperbolic, Parabolic and Elliptic equations, Models of flow, Total derivative, Continuity Equation, Momentum Equation, Energy equation, Navier-Stokes equation for viscous flow, Euler equation for inviscid flow, Physical boundary conditions, Forms of governing Equations suited for CFD, Conservation form of the equations, Time marching and Space marching, Introduction of Finite differences, Finite difference equations using Taylor Series Expansion and polynomials, Explicit and Implicit approaches, Uniform and unequally spaced grid points, parabolic, hyperbolic, elliptical partial differential equations, Finite Difference formulations using Explicit and Implicit methods, ADI method for Elliptical equations, General transformation of the equations, Metrics and Jacobians, transformed governing equation of the CFD, Boundary fitted coordinate system, Algebraic and Elliptic grid generation technique, Adaptive Grids, Discrete perturbation stability analysis, Von-Neumann Stability analysis, Error analysis, artificial dissipation and dispersion.

Course Outcomes

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

CO1: Derive the governing equations and understand the behavior of the governing equations.

CO2: Analyze the type of characteristics of equation and able to solve numerically. equations.

CO3: Analyze various methods of grid generation.

Books and References

1. Computational Fluid Dynamics: The Basics with applications, Anderson, J.D. (Jr), McGraw - Hill Book Company, 2017, Indian Edition.
2. Computational Fluid Dynamics, Vol. I, II and III, Hoffman. K.A., and Chiang, S.T., Engineering Education System, Kansas, USA, 4th Edition, 2000
3. Computational Fluid Dynamics, Chung, T.J., Cambridge University Press, 2nd Edition, 2014

Advanced Fluid Mechanics

Course Code: ME-613 Course Type: Core

Course Contact Hrs.: 4L Course Credit: 4

Course Objectives:

- Ascertain basic concepts of the fluid mechanics and apply the concepts in the analysis of fluid flow problems
- Analyze the stress, strain and forces involving in the fluid element and to derive the governing equations
- Find the exact and approximate solutions of the governing equations for realistic flow situations
- To understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.

Course Content

Fluid Kinematics, Reynold's transport theorem, Derivation of mass, momentum and energy equations, Integral and differential formulations, Navier-Stokes and energy equations Dimensionless forms and dimensionless numbers - Solution of Navier-Stokes equations, Euler's equation and Bernoulli's equation, applications of Bernoulli's equation. irrotational incompressible flows, Couette flow, Hagen-Poiseuille flow, Flow between coaxial and concentric rotating cylinders, Hydrodynamic theory of lubrication, Creeping flows, Unsteady motion of flat plate**,** Different types of flow patterns, complex potential conformal mapping. Momentum integral approach. Turbulent flows - Reynolds equation and closure problems, free and wall bounded shear flows- Prandtl and von Karman hypothesis- Universal velocity profile near a wall- flow through pipes Boundary layer concept, Boundary layer theory and its applications to laminar boundary layers, jets, wakes and stagnation regions in external and internal flows, Prandtl's equations - Blasius solution-skin friction coefficient

Course Outcomes

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

CO1: Identify and obtain the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.

CO2: Recognize these principles written in form of mathematical equations.

CO3: Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics

Books and References

1. Introduction to Fluid Mechanics, Fox, R.W.,Pritchard, P. J. and McDonald, A. T., Wiley, 8th Edition, 2011
2. Viscous Fluid Flow, White, F. M., Tata McGraw Hill Book Company, 3rd Edition, 2006
3. Foundations of Fluid Mechanics, Yuan, S. W., Prentice Hall of India, 4th Edition, 1988
4. Boundary Layer Theory, Schlichting, H and Gersten, K, Springer, 8th Edition, 2014
5. Fluid Mechanics, Muralidhar, K and Biswas, G., Alpha Science International Ltd, 2nd Edition, 2005

Thermal Engineering Lab

Course Code: ME-614 Course Type: Core

Contact Hours/Week: 4P Course Credits: 2

Course Objectives

- To impart practical exposure of various thermal engineering systems.
- To study the concepts, applications of the thermal engineering laboratory
- To demonstrate and conduct experiments, interpret and analyze results of IC Engine testing.

Details of Experiments

1. To conduct Morse test on 4-stroke multi cylinder petrol engine to establish friction power, mechanicalefficiency.
2. To determine the volumetric efficiency and mass flow rate of the single stage air compressor.
3. To understand the fabrication of thermocouple (T type) and its use for temperature measurement.
4. Measurement of pressure using projection manometer.
5. To calculate heat transfer rate and effectiveness of shell & tube heat exchanger.
6. To calculate heat transfer rate and effectiveness of double pipe heat exchanger.
7. To study the horizontal fire tube boiler.
8. Performance test on Pelton wheel turbine.
9. To study the characteristics of the double acting reciprocating pump test rig at variable speed.
10. Determination of various radiative properties such as emissivity and Stephan Boltzmann constant.
11. To determine the coefficient of performance of vapor absorption refrigeration systems.
12. To determine the coefficient of performance of individual cascades of cascade refrigeration systems.

The concerned course coordinator will prepare the actual list of experiments/ problems at the start of the semester based on the above generic list.

Course Outcomes

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

CO1: Calculate the performance of internal combustion engines and air compressor

CO2: Draw and analyze performance curves of these machines/systems.

CO3: Evaluate the Coefficient of performance various refrigeration systems.

Books and References

1. Internal Combustion Engines by Ganesan.V, Tata McGraw Hill, 2007
2. Internal Combustion Engine Fundamentals by J.B. Heywood, McGraw-Hill, 2nd Edition, 2018
3. Refrigeration & Air conditioning by C.P. Arora, Tata McGraw Hill, 3rd Edition, 2008
4. Turbo Compressors and Fans by S.M.Yahya, Tata McGraw-Hill, 4th Edition, 2010

Computational Fluid Dynamics

Course Code: ME-621 Course Type: Core

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart the knowledge and concept of FVM for different fluid flow & heat transfer problems.
- To impart knowledge about grid generation.
- To impart knowledge on several CFD algorithms.

Course Content

Role of CFD and its application, future of CFD, physical meaning of the divergence of velocity, different forms of GE’s, initial and boundary condition, FVM for 1D steady state diffusion, 2D steady state diffusion, 3D steady state diffusion, Solution of discretized equation-TDMA scheme for 2D and 3D flows. FVM for 1D steady state convection-diffusion, central differencing scheme, conservativeness, boundedness, transportiveness, upward differencing scheme, hybrid differencing scheme for 2D and 3D convection-diffusion, power law scheme, QUICK scheme, 1D unsteady heat equation (Explicit, Crank-Nicolson, Fully implicit schemes), implicit methods for 2D and 3D problems, discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations, concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm, Inlet boundary conditions, outlet boundary conditions, Wall boundary conditions, constant pressure boundary condition, symmetry boundary condition, uncertainty in CFD, latest development in CFD techniques and newer applications.

Course Outcomes

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

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

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

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

Books and References

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H.K. Versteeg and W. Malalasekara, Pearson Education, 2007
2. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing, 1995
3. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill, 1st Edition, 2018
4. Computational Techniques for Fluid Dynamics Volume I & II by C.A.J. Fletcher, Springer, 2nd Edition, 1991

Convective Heat Transfer

Course Code: ME-622 Course Type: Core

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- Demonstrate a fundamental understanding of physical principles associated with the study of convective heat transfer.
- To impart the knowledge of the fundamental principles governing convective heat transfer.
- To develop the skills necessary for analysing and solving convective heat transfer problems encountered in various engineering applications.

Course Content

Concepts, conservation principles and laws; Equations of continuity, momentum, and energy; Dimensional analysis and similarity principles, Concept of boundary layer, velocity and thermal boundary layer thickness, integral solutions and similarity solutions, laminar forced flow over a flat plate, thermal boundary layer on an isothermal/constant surface heat flux flat plate, flat plate with varying surface temperature, Hydrodynamic entrance length, fully developed flow, heat transfer to developed and developing flow, laminar forced convection in pipe and ducts, dimensional analysis, some exact solutions of Navier-Stokes equations, Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for laminar flow, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer, Governing equations for averaged turbulent flow field (RANS), Reynolds, Prandtl-Taylor and von Karman Analogies, Turbulence Models (Zero, one and two equation models), Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations

Course Outcomes

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

CO1: Demonstrate a comprehensive understanding of the fundamental principles governing convective heat transfer, including boundary layer theory, flow regimes, and convection correlations.

CO2: Analyse and calculate heat transfer coefficients for various flow configurations, distinguishing between laminar and turbulent flows and applying appropriate correlations.

CO3: Apply the concepts of natural and forced convection to analyse heat transfer in different scenarios, understanding the significance of each mechanism in engineering applications.

Books and References

1. Arpaci, V. S. and Larsen, P. S., Convection Heat Transfer, Prentice Hall, 1984
2. Burmeister, L.C., Convection Heat Transfer, John Wiley & Sons, 1993
3. Bejan, A. Convection Heat Transfer, 3rd Ed., John Wiley & Sons, 2004
4. Kays, W. M. and Crawford, M. E., Convective Heat and Mass Transfer, Tata McGraw Hill 2005.

Compressible Flows

Course Code: ME-623 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To understand the basic difference between incompressible and compressible flow.
- To study the phenomenon of shock waves and its effect on flow.
- To gain the gas dynamics theory and their applications.

Course Content

Ideal gas relationship, adiabatic energy equation, Mach number and Its significance, Mach waves, Mach cone, and Mach angle, static and stagnation states, relationship between stagnation temperature, pressure, density and enthalpy in terms of Mach number, stagnation Velocity of sound, reference speeds, various regions of flow, effect of Mach number on compressibility, area velocity relationship, one dimensional isentropic flow in ducts of varying cross-section- nozzles and diffusers, operation of nozzles under varying pressure ratio, mass flow rate in nozzles, critical properties and choking, area ratio as function of Mach number, Development of shock wave, thickness of shock wave, governing equations, strength of shock waves, Prandtl-Mayer relation, Rankine-Hugoniot relation, Mach number in the downstream of normal shock, variation of flow parameters across the normal shock, normal shock in Fanno and Rayleigh flows, Simple heating relation of a perfect gas, Rayleigh curve and Rayleigh flow equations, variations of flow properties, maximum heat transfer, tables and charts for Rayleigh flow. Fanno curve and Fanno flow equations, Solution of Fanno flow equations, Variation of flow properties, variation of Mach number with duct length.

Course Outcomes

Upon successful completion of the course, the students will

CO1: Understand and grasp of the basic principles of compressible flow have creative thinking and a deeper understanding and intuitive feel for compressible flows and compressible flow theory.

CO2: Have basic understanding of the underlying principles of the technology pertinent to the theory and design of devices with compressible flow.

CO3: The student will be aware of the basic principles and its application in aviation industry.

Books and References

1. Fundamental of Compressible flow by S. M. Yahya, New age international Publication, Delhi, 2003.
2. Fundamentals of Compressible Fluid Dynamics by P. Balachandran, PHI Learning, New Delhi, 2006.
3. Gas Dynamics by E. Rathakrishnan, PHI Learning Pvt. Ltd, 7th edition, 2020
4. Fundamentals of Gas Dynamics by V. Babu, Ane/Athena Books, 2020

Computational Lab

Course Code: ME-624 Course Type: Core

Contact Hours/Week: 4P Course Credits: 2

Course Objectives

- To impart computational exposure of various thermal physical situations.
- Grid generation and boundary conditions for complex geometry.
- To formulate problems followed by conducting simulations and interpretation of results.

Details of Experiments

1. Temperature distribution for steady state heat conduction.
2. Temperature distribution for unsteady state heat conduction by using explicit method.
3. Temperature distribution for unsteady state heat conduction by using implicit method.
4. Tri-diagonal matrix using Thomson algorithm.
5. Solution of Lid driven cavity problem.
6. Numerical solutions of quasi-one dimensional nozzle flows.
7. Modeling of flow around streamlined bodies using CFD solvers.
8. Modeling of flow around Bluff bodies using CFD solvers.
9. Simulation on natural convection flow problems using CFD solvers.
10. Simulation on mixed convection problems, laminar flow, problems using CFD solvers.
11. Simulation on mixed convection problems, turbulent flow, problems using CFD solvers.
12. Exercises on hydrodynamic and thermal boundary layer problems using CFD solvers.

The concerned course coordinator will prepare the actual list of experiments/ problems at the start of the semester based on the above generic list.

Course Outcomes

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

CO1: Estimate temperature distribution for various systems.

CO2: Introduction to CFD solvers.

CO3: Solve various thermal related problems by using CFD solvers.

1. An Introduction to Computational Fluid Dynamics: The Finite Volume Method by H.K. Versteeg and W. Malalasekara, Pearson Education, 2007
2. Computational Fluid Flow and Heat Transfer by K. Muralidhar and T. Sundararajan, Narosa Publishing, 1995
3. Numerical Heat Transfer and Fluid Flow by S.V. Patankar, McGraw-Hill, 1st Edition, 2018

Turbomachines Design

Course Code: ME-711 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To Introduce the fundamental Concepts Related to Design of Turbines
- To Introduce the fundamental Concepts Related to Design of Compressor
- To Enable the Students to Understand the Performance of Various Types of Gas Turbines

Course Content

Definitions of turbo machines, parts of turbo machines, concept and method of energy transfer in turbomachines, degree of reaction, efficiencies of turbomachine, stage efficiency or polytropic efficiency, principle of operation of centrifugal compressors, work done and pressure rise, stage pressure, stage efficiency, degree of reaction, dimensionless parameters, slip factor, velocity triangles, Euler work, design of impeller, design of diffuser, design of vane less diffuser, design of volute casing, basic operation of axial flow compressors, elementary theory, factors affecting stage pressure ratio, blockage in the compressor annulus, degree of reaction, three dimensional flow, design process, blade design, calculation of stage performance, compressibility affects, off-design performance, axial compressor characteristic. elementary theory of axial flow turbine, vortex theory, choice of blade profile, pitch and chord, estimation of stage performance, overall turbine performance, radial flow turbine, performance prediction of gas turbines, component characteristics, off-design operation of the single shaft turbine, free turbine engine and jet engine, methods of displacing the equilibrium running line, incorporation of variable pressure losses.

Course Outcomes

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

CO1: Design Compressors and Turbines.

CO2: Establish Performance Characteristics Curves of Thermal Turbomachines.

CO3: Assess & Analyze the Performance Outcomes of Thermal Turbomachines.

Books and References

1. Centrifugal compressors: A basic guide by M.P. Boyce, Penn Well Books, 2003
2. Gas Turbine theory by Cohen, Rogers, Tata McGraw-Hill, 2001
3. Axial Flow Compressors: A strategy for aerodynamic design and Analysis by R. Aungier, ASME Press, 2003
4. Turbine Compressors and Fans by S.M.Yahya, Tata McGraw-Hill, 4th Edition 2010

Design and Analysis of Experiments

Course Code: ME- 712 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- Design robust and efficient experiments using various design types and principles.
- Analyze experimental data using advanced statistical methods like ANOVA, regression analysis, and factorial designs.
- Apply experimental design principles to real-world engineering and scientific research problems.

Course Content

Experimental Design Principles, Strategy of Experimentation, Difference Between Field Experiments and Laboratory Experiments, Applications of Experimental Design, Experimental Data analysis**,** Concept of hypothesis, Alternate and null hypothesis, Concept of Confidence Level, type i and ii errors, measures mean median mode and central tendency, analysis of variance (ANOVA), Correlation and regression analysis, Uncertainty and Reliability of Data, Factorial Experimental Design, Factors Levels, Interactions, Two Factor Factorial Design and General Factorial Design, Fitting Response Curves and Surfaces, Blocking in a Factorial Design. Two-Level Factorial Designs; 2^2 and 2^3 Design, General 2^k Design: Factor Effects, Factor Interactions, Fractional Factorial Design, Central Composite Designs, Response Surface Methodology, Robust Parameter Design, Main Effects and Interaction Effects, predictor equation and its coefficients, Parameter Optimization. Application of RSM in engineering problems, Taguchi's Quality Philosophy, Types of Orthogonal Arrays, Selection of Standard Orthogonal Arrays, Evaluation of Sensitivity to Noise. Signal to Noise Ratios for Static Problems: Smaller-the-Better Type, Nominal-the –Better-Type, Larger-the-Better Type

Course Outcomes

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

CO1: design experiments using methodologies like factorial, fractional factorial, and response surface designs.

CO2: apply advanced statistical methods to experimental data, interpret results accurately, and use software tools for analysis.

CO3: translate theoretical concepts into practical applications, conduct independent research, and present findings effectively.

Books and References

1. Design and Analysis of Experiments by Douglas C. Montgomery, John Wiley & Sons, 9th Edition, 2020
2. Design and Analysis of Experiments by Angela Dean Daniel Voss, Springer, 1st Edition, 1999
3. Experimental Design and Analysis by Howard J. Seltman, Carnegie Mellon University
4. Design and Analysis of Experiments by Gary W. Oehlert, W.H Freeman Publisher, 2000

Design of Refrigeration Systems

Course Code: ME- 713 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- Apply refrigeration concepts to address technical and societal problems with creativity, imagination, confidence and ethics
- To carry out the thermodynamic analysis of conventional and alternative refrigeration systems.
- To analyze components like compressors, condenser, evaporator, and expansion valve in detail way

Course Content

Recapitulation of Vapour Compression and Vapour Absorption refrigeration Systems, Thermodynamic Analysis of Ejector based Refrigeration Systems, Refrigerant Selection Criteria, Future Refrigerants, Analysis of Thermoelectric and Vortex Tube Refrigeration Systems, classification of refrigerant compressors, Performance aspects of ideal compressors with and without clearance, working principle and characteristics of a fixed vane, rolling piston type compressor, multiple vanes, rotary compressor, twin-screw type compressor, single-screw type compressor, centrifugal compressor, velocity diagrams, classifications of condensers based on the external fluid used, analysis, classification of evaporators natural or forced convection type, flooded or dry type, refrigerant flow inside the tubes or outside the tubes, salient features of: natural convection coils, flooded evaporators, shell-and-tube type evaporators, shell-and-coil evaporator, double pipe evaporators, Baudelot evaporators, direct expansion fin-and-tube type evaporators, plate surface evaporators, plate type evaporators, thermal design aspects of refrigerant evaporators, enhancement of boiling heat transfer, concept of Wilson's plot, expansion devices, capillary tubes, reciprocating compressor performance characteristics, Condenser performance characteristics, Evaporator Performance, Expansion valve Characteristics, Condensing unit, Performance of complete system - condensing unit and evaporator, Effect of expansion valve.

Course Outcomes

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

CO1: carry out the thermodynamic analysis of conventional and alternative refrigeration systems.

CO2: analyse performance of refrigerant compressors.

CO3: analyse the components like evaporator, condenser, and expansion devices in detail way.

Books and References

1. Refrigeration and Air Conditioning by C.P. Arora, Tata McGraw-Hill, 3rd Edition, 2008
2. Refrigeration and Air Conditioning by Stooker W.F, 2nd Edition, 1982
3. Handbook of Air Conditioning and Refrigeration by Shan K. Wang, Tata McGrawHill, 2000
4. Refrigeration and Air Conditioning by Arora & Domkundwar , Dhanpat Rai and Sons, 2nd Edition, 2006

Design of Heat Exchangers

Course Code: ME-714 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart knowledge on the basic design methodologies of heat exchanger.
- To understand the principles and design methodologies of double pipe, shell and tube and compact heat exchangers.
- To introduce heat transfer enhancement technique and performance evaluation of heat exchangers.

Course Content

Basic concepts, classification of heat exchanger, Selection of heat exchanger, basic design methodologies for heat exchanger, overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multi-pass and cross flow heat exchanger, effectiveness-NTU method for heat exchanger analysis, fouling, rating and sizing problems, heat exchanger design methodology, Thermal and hydraulic design of Inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop, performance and design calculations, Basic components, design Procedure of heat exchanger, J-factors, conventional design methods, Bell-Delaware method, Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop, introduction to pinch analysis

Course Outcomes

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

CO1: Understand the basic concept and design methodology of heat exchangers.

CO2: Determine general design requirements for different types of heat exchangers.

CO3: Able to apply the basic knowledge of fluid mechanics, heat transfer, and material properties in design calculations.

Books and References

1. Heat Exchangers – Selection Design and Construction by Saunders, Longmann Scientific and Technical, NY, 1988
2. Compact Heat Exchangers by Kays and London, McGraw Hill. 3rd Edition, 1984
3. Heat Exchangers by Martin, Hemisphere Publications Corp., Washington, 1983
4. Fundamentals of Heat Exchanger Design by Shah and Sekulic, Wiley, 2003

Design of Thermal Systems

Course Code: ME-715 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart the knowledge about the concept of design of thermal systems.
- To provides the basic understanding of modelling and designing the thermal systems.
- To develop representational modes of real processes and systems

Course Content

Thermal systems, engineering design, workable and optimal designs. Overview of thermal systems and their importance in engineering applications, Maximum efficiency and energy conservation, minimum cost/losses, multi-criteria, functional reliability of system components, Types of models with examples, mathematical modelling of processes and components, system models, identification of operating variables; simulation techniques, Maximum and minimum conditions, optimization parameters, levels of optimization, mathematical representation of problem, optimization procedures including introduction to some non-traditional methods, Economic Considerations, Present and future work factors, gradient factors, rates of return, life cycle cost.

Course Outcomes

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

CO1: Understand the aspects of designing of thermal systems.

CO2: Solve the problem using numerical simulation by choosing the design variables which affects the problem.

CO3: Explain economic aspects of designing and able to apply different techniques of optimization applicable to thermal system.

Books and References

1. Hodge, B. K.and Taylor, R. P., Analysis and Design of Energy Systems, Prentice Hall, 1999
2. Suryanarayana, N. V. and Arici,O.,Design and Simulation of Thermal Systems, Penguin Books Ltd., 2004
3. Jaluria, Y., Design and Optimization of Thermal Systems, CRC Press, 2007
4. Burmeister, L.C., Elements of Thermal Fluid Systems, Prentice Hall, 1998
5. Bejan, A., Tsaatsaronis,G. and Moran, M., Thermal Design and Optimization, Wiley, 1996
6. Stoecker, W. F., Design of Thermal Systems, Tata McGraw Hills, 4th Edition, 2004

Gas Turbines and Jet Propulsion

Course Code: ME-721 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To get awareness and familiarize with the latest developments in turbojet propulsion systems.
- To know principles of jet propulsion and rocketry.
- To study solid and liquid rocket propulsion system.
- To know ramjet and integral rocket ramjet propulsion system.

Course Content

System of operation of gas turbines-constant volume and constant pressure gas turbines; thermodynamics of Brayton cycle; regeneration-inter-cooling, reheating and their combinations; closed cycle and semi-closed cycle gas turbines; Ideal shaft power cycles and practical shaft power cycles and their analysis, Layout of turbo jet engine, turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis, flight performance: forces acting on vehicle – basic relations of motion – multistage vehicles, Fundamentals of jet propulsion, Rockets and air breathing jet engines – Classification – turbo jet, turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines, Solid and Liquid Rocket Propulsion System, Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification, and comparison of IIRR propulsion systems.

Course Outcomes

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

CO1: Understand and Build various concepts of turbojet propulsion systems.

CO2: Distinguish the jet propulsion and rocketry.

CO3: Categorize solid and liquid rocket propulsion system.

CO4: Interpret ramjet and integral rocket ramjet propulsion system

Books and References

1. J Mattingly, Elements of Gas Turbine Propulsion, McGraw-Hill Publications, 1996
2. G.P. Sutton and O. Biblarz, Rocket Propulsion Elements, John Wiley & Sons, 2011
3. G.C. Oates, Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA, New York, 1997
4. N.A. Cumpsty, Jet Propulsion, Cambridge University Press, 3rd Edition, 2018
5. P G Hill and C R Peterson, Mechanics and Thermodynamics of Propulsion, Addison Wesley, 2nd Edition, 2010
6. M J Zucrow, Aircraft and Missile Propulsion (Vol. I and II), John Wiley, 1958
7. W W Bathie, Fundamentals of Gas Turbines, John Wiley, 1996
8. H Cohen, G F C Rogers and H I H Saravanamuttoo, Gas Turbine Theory**,** Addison Wesley, 7th Edition, 2018

Solar Energy Technologies

Course Code: ME-722 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- Design and analysis of thermal and electrical energy storage systems
- Design and analysis of solar thermal and photovoltaic systems
- Understanding of solar passive architecture

Course Content

Extra-terrestrial and terrestrial radiations, measurement, solar radiation geometry, computation of solar radiation on horizontal and tilted surfaces. Solar flat plate collectors, performance analysis, estimation of losses, collector efficiency and heat removal factor, testing procedures, solar collectors designs and performance parameters, parabolic concentrators, Fresnel collectors, Heliostats, performance of the collectors, Solar process load building loss coefficient, cooling load, solar water heating, integral collector storage systems, water heating in space heating and cooling, testing and rating of solar water heater, economics considerations, heat pump systems, different solar cell technologies: crystalline silicon solar cell, thin film solar cell, Tandem solar cell , photovoltaic system, components and configurations, off grid and grid connected PV systems, PV system designs and economics, Thermal comfort, heat transmission in buildings, bioclimatic classification, passive heating and cooling concepts, evaporative and radiative cooling, water, and earth for cooling; shading - paints and cavity walls for cooling, roof radiation traps, earth air-tunnel, energy efficient landscape design, thermal comfort, concept of solar temperature and its significance, instantaneous heat gain through building envelope

Course Outcomes

On completion of the course, student will be able to

CO1: Design and analyse the solar flat plat collectors and air heaters.

CO2: Examine the performance of concentrator collectors and TES systems.

CO3: Identify the principles of building heating and solar cooling methods.

Books and References

1. Duffie J. A. and Beckman W.A.; Solar Engineering of Thermal Processes, John Wiley, 4th Edition, 2013
2. Solanki C. S.; Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India, 2015
3. Nayak J. K. and Sukhatme S. P., Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 3rd Edition, 2008
4. Goswami D. Y.; Principles of Solar Engineering, Taylor and Francis, 4th Edition, 2022
5. Tiwari G. N.; Solar Energy: Fundamentals, Design, Modeling and applications, Narosa Publications, 1st Edition, 2013

Energy Conservation and Waste Heat Recovery

Course Code: ME-723 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To enable students to understand of the concept of waste to energy.
- To understand the design of waste heat recovery systems efficient power cycles and power generation system.
- To identify sources of energy loss and power saving.

Course Content

Potential of waste heat recovery (WHR), Source of waste heat, Utilization and category of waste heat, Relationship of WHR with other energy issues, Thermodynamic principle of waste heat recovery, Second law efficiency, Combined cycle, Combine cycle, Co-generation, Trigeneration, Poly-generation, Heat recovery steam generator, Thermodynamic cycle for low temperature application, Introduction and classification of heat exchanger, Methods and Analysis of heat exchanger, Regenerators, Special recuperates, Heat exchanger network analysis by Pinch technique, Heat Pipe, Introduction to direct energy conversion device, Thermoelectric generation (TEG) basics, Thermoelectric element, Application of TEG, TEG performance analysis, Performance optimization, Heat pump system and application, Industrial process heating heat pump, Magneto hydro dynamic generation, Thermo-ionic generation, Thermo-photovoltaic generation, Waste heat Recovery from Incinerator plant, Prime mover exhausts, Case studies and energy economics**.**

Course Outcomes

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

CO1: Students will be able to understand the principle and methods of application of low temperature heat.

CO2: Check energy and fuel consumption and a wastage in existing facilities through effective metering and cost analysis.

CO3: Analyze different methods of waste heat recovery.

Books and References

1. Heat Recovery System by D. A. Reay, E & F. N. Span, London. 1979
2. Waste Heat Recovery Methods and Technologies, C. C. S. Reddy and S. V. Naidu, National University of Singapore, 2022
3. Organic Rankine Cycle Power Systems 1st Edition Technologies and Applications, Ennio Macchi Marco Astolf, Woodhead Publishing, 2016
4. Fundamental of Heat Exchanger Design by Ramesh K. Sash and Dusan P. Sekulic, Wiley, 2003
5. Thermoelectric Handbook by D. M. Rowe, CRC Press, 2018

Hydrogen Energy

Course Code: ME-724 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To identify the potential of hydrogen to fulfill the future energy requirements.
- To impart comprehensive and logical knowledge of hydrogen production, storage and utilization.
- To impart the knowledge of various storage and utilization technologies of hydrogen.

Course Content

Physical and chemical properties, salient characteristics, relevant issues, and concerns. Producing Hydrogen: Electrolysis, Reforming and Other processes, Units of measurement, Barriers and Challenges. Reforming Natural Gas and Liquids: Steam Reforming Process and their Barriers. Producing Hydrogen from Coal: Coal gasification. Biomass and waste-based hydrogen production. Electrolysis of Water. Hydrogen from Solar Power: Solar water-splitting, Photolytic processes, Photo-biological processes. Wind-Powered Hydrogen Production, Hydrogen production using Other Renewables, Compressed gas tanks, Liquefied gas tanks. Advanced Storage Technologies: Metal hydrides, Chemical hydrides, Carbon materials. Comparison with other fuels, Leak detection, Safety practices, codes, and standards, Barriers and challenges, Problems of Hydrogen Transport, Hydrogen pipelines, Transportation economics, Fueling Station Infrastructure, and equipment, Electrolysis-based fueling stations, hydrogen utilization, power plant, Marine applications, Hydrogen powered vehicles, Hydrogen dual fuel engines, Hydrogen safety aspects in vehicle, Backfire, Pre-ignition, Hydrogen emission, NOx and other emissions

Course Outcomes

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

CO1: Identify the different hydrogen production methods.

CO2: To understand environmental hazards associated with the use of hydrogen energy technology.

CO3: To understand various storage and utilization technologies of hydrogen fuel.

CO4: To understand numerous Hydrogen Transportation and Distribution methods.

Books and References

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005
2. Bent Sorensen (Sorensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier Academic Press, UK, 3rd Edition, 2018
3. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA, 2003
4. Peter Hoffman, Tomorrows Energy: Hydrogen, Fuel cells and the prospects for a cleaner planet, MIT Press, Cambridge, London, England , 2001

Cryogenic Engineering

Course Code: ME-725 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To study about the property of cryogenic fluid and material
- To study about various gas liquefaction systems for cryogenic application including cryocoolers.
- To study about cryogenic insulation and vacuum technology for cryogenic applications.

Course Contents

Historical review, application areas, properties of cryogenic fluids, Properties of Material at cryogenic temperature, Methods of Production of Low Temperature**,** Joule Thomson Expansion and Effect, Expression of Joule Thomson Coefficient, Maximum Inversion Temperature, Adiabatic Expansion, Linde Hampson System, Precooled Linde Hampson System, Linde Dual Pressure System, Claude System, Kapitza & Heylandt System, Collins System, Introduction, Classification of Cryocoolers, Stirling, Gifford-McMahon, Pulse tube, Joule Thomson Cryocoolers, Introduction & Classifications, Mass, Reflective & Vacuum Insulation, Evacuated Powders, Opacified Powders, Multilayer Insulations, Vacuum Technology

Course Outcomes

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

CO1: Select suitable cryogen and material for development of cryogenic system for different applications.

CO2: Carry out design and analysis of gas liquefaction system and cryogenic refrigeration systems including Cryocoolers.

CO3: Select proper cryogenic insulating material and designing of cryogenic insulation

Books and References

1. Hastlden, C., Cryogenic Fundamentals, Academic Press, 2001
2. Barron R., Cryogenic Systems, Plenum Press, 2001
3. Walker G., Cryocoolers, Springer, 2014
4. Mikulin, Y., Theory and Design of Cryogenic systems, MIR Publication, 2002.
5. Barron, R. F., Cryogenics Systems, Oxford Press., USA, 2002

Heading, Ventilation and Air Conditioning

Course Code: ME-726 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To introduce the advanced psychrometric processes and study of comfort and design condition of HVACs.
- To impart knowledge about load calculations for the designing of HVACs.
- To impart knowledge for the design of HVAC equipment.
- To understand the design principles of transmission and air distribution system.

Course Content

Recapitulation of Psychrometry and process used in HVAC, Cooling Towers, Summer and winter Air Conditioning, Inside and Outside Design Conditions, Thermal Comfort, Load Classification, Solar Terminology, Calculation of Solar Radiation Intensities, Solar Heat Gain through Transparent Bodies (e.g. glass), Transmission Heat Gain through Building Materials, Methods of Calculating Cooling Load through Building Material, Internal Load, Infiltration and Ventilation Loads, Miscellaneous Loads, Cooling and Heating Load Calculation Methods, applied psychrometry, Indoor Air Quality, Air Cleaner Performance & Classification Filter location, odour control, Ventilation need, principles and types, Measurement of Temperatures, Pressure, RH, Air Velocity, Air Quality Measurement, Pressure Drop Calculation, Air Duct Design, Material and Construction, Duct Design Methods- Velocity Reduction, Equal Pressure Drop, Static Regain, Room Air Distribution Systems, Fans and Blowers for HVAC, Measurement in HVAC Systems, HVAC Systems and Classifications, Heat Pumps, All air systems. Air water systems. Water and DX systems; thermal storage, Passive cooling concepts-earth tunnels, Method of production of dry air, desiccant Cooling.

Course Outcomes

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

CO1: Understand the principle of psychrometric process and design conditions of the air conditioners

CO2: Calculate the cooling and heating load of the air conditioners

CO3: Design the air distribution and transmission systems

Books and References

1. Refrigeration and Air Conditioning by C.P. Arora, TMH Publication, 3rd Edition, 2008
2. Refrigeration and Air Conditioning by Manohar Prasad, New Age International Publishers, 2nd Edition, 2006
3. Refrigeration and Air Conditioning by R.C. Arora, PHI Publication, 2012
4. Refrigeration & Air Conditioning by W.F. Stoecker, TMH Publication, 2nd Edition, 1982

Multi-Phase Flows

Course Code: ME-731 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart knowledge about fundamental concepts, principles and application of multiphase flow.
- To impart knowledge about the concept of bubble formation and bubble dynamics.
- To impart knowledge on aspects of hydrodynamics of solid-liquid and gas-solid flows.

Course Content

Definition of multiphase flow, Flow patterns Types & applications, Common terminologies, One dimensional steady homogenous flow, Concept of choking and critical flow phenomena, one dimensional steady separated flow model, Phases are considered together but their velocities differ, Phases are considered separately, flow with phase change, Flow in which inertia effects dominate, energy equations, Separated Flow Model for Atratified and Annular flow, General Theory of Drift Flux Model, Application of Drift Flux Model to Bubbly and Slug Flow. Hydrodynamics of Solid-Liquid and Gas-Solid Flow, Principles of Hydraulic and Pneumatic Transportation, Introduction to Three Phase Flow, Measurement Techniques for Multiphase Flow. Flow Regime Identification, Pressure Drop, Void Fraction and Flow Rate Measurement

Course Outcomes

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

CO1: Understand the Fundamentals of Multi-Phase Flow.

CO2: Analyze Multi-Phase Flow with Inertia Effects.

CO3: Analyze Flow Regimes with Appropriate Models.

CO4: Measure Parameters in Multi-Phase Flow

Books and References

1. Fundamentals of Multiphase Flow by C. E. Brennen, Cambridge University Press, New York, 2005.
2. Two Phase Flow by Butterworth and Hewitt
3. Liquid-Vapor Phase-Change Phenomena by V P Carey, Hemisphere Pub. Corp., 1992
4. Graham B Wallis, One dimensional two phase flow, McGraw Hill, 1969.

Micro-Fluidics

Course Code: ME-732 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To impart knowledge about fundamentals of micro-scale flows.
- To impart knowledge about the various Microfabrication Techniques.
- To impart knowledge about design of microfluidic components and few applications of microfluidic systems.

Course Content

Origin, definition, benefits, challenges, commercial activities, physics of miniaturization, scaling laws, intermolecular forces, states of matter, governing equations, constitutive relations. gas and liquid flows, boundary conditions, slip theory, transition to turbulence, low re flows, entrance effects, stokes drag on a sphere, time-dependent flows, two phase flows, thermal transfer in microchannel. hydraulic resistance and circuit analysis, straight channel of different cross-sections, surface tension and interfacial energy, Young-Laplace equation, capillary length and capillary rise, interfacial boundary conditions, Marangoni Effect, materials, clean room, silicon crystallography, miller indices. oxidation, photolithography- mask, spin coating, exposure and development, etching, bulk and surface micromachining, wafer bonding, polymer microfabrication, PMMA/COC/PDMS substrates, hot embossing, fluidic interconnections, micro valves, thermo-pneumatic, thermomechanical, piezoelectric, electrostatic, electromagnetic and capillary force valves, micro-flow, differential pressure, drag, lift, Coriolis flow and thermal flow sensors, kinetics & dynamics of a droplet, t and cross-junction, droplet formation, breakup and transport. principles of separation and sorting of micro particles, micro reactors, design considerations, phase reactors, PCR, design consideration for PCR reactors

Course Outcomes

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

CO1: Understand the Fundamentals of Fluid Flows at Micro-Scale Including Intermolecular Forces.

CO2: Understand the Principles of Microfabrication with Silicon and Polymer Substrates.

CO3: Analyze the Design of Various Microfluidic Components including Micro Pumps, Micro Mixers, Micro Valves.

Books and References

1. Fundamentals and applications of Microfluidics by N. T. Nguyen, and S. T. Werely, Artech House Inc., 2002.
2. Fundamentals of Microfabrication by M. J. Madou, CRC Press, 2002.
3. Introduction to microfluidics by P. Tabeling, Oxford University Press Inc., 2005.
4. Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices by B. J. Kirby, Cambridge, 2010

Turbulent Flows

Course Code: ME-733 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To Provide the Knowledge of Basic Fundamentals of Turbulent Flows.
- To provide the knowledge of Mathematical analysis of Turbulent Flows.
- To Provide the Knowledge of Modeling of Turbulent Flows.

Course Content

Nature of turbulent flows, irregularity, diffusivity, dissipation, wide spectrum, origin of turbulence, eddy motions and length scales, Reynolds averaged Navier Stokes Equations, equations for Reynolds stresses, turbulence kinetic energy and energy of mean flow convection, production and dissipation of turbulence, re-distribution, turbulent diffusion, mixing layer, turbulent wakes and jets, grid turbulence, channel and pipe flows, Reynolds stresses, turbulent boundary layer equations, logarithmic-law of walls, turbulent structures, eddy viscosity/mixing-length models, two-equation models of turbulence: standard k-ε and $k - \omega$ model, Reynolds-stress model, near-wall treatment, Introduction to LES and DNS

Course Outcomes

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

CO1: Introduce the concept of turbulent flows and its various properties.

CO2: Study free shear and wall bounded turbulent flows.

CO3: Study various turbulent modelling techniques.

Books and References

1. Turbulent Flows by Stephen B. Pope, Cambridge University Press, 2000
2. Turbulence by P. A. Davidson, Oxford University Press, 2004
3. Turbulent flows by G. Biswas, and V. Eswaran, Narosa Publishing House, 2002
4. A first course on turbulence by H. Tennekes, and J. L. Lumley, MIT Press, 1972

Fluid and Heat Transport through Porous Media

Course Code: ME-734 Course Type: Program Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To Provide the Knowledge of Basic Fundamentals of Fluid Flow in Porous Medium.
- To Provide the Knowledge of Basic Fundamentals of Heat Flow (Natural Convection) in Porous Medium.
- To Provide the Knowledge of Basic Fundamentals of Heat Flow (Forced Convection) in Porous Medium.

Course Content

Porosity, permeability; capillary models, hydraulic radius model, drag model for periodic structure, percolation and tortuosity, volume averaging, rev, first law of thermodynamics, local thermal equilibrium, porous medium energy equation, second law of thermodynamics, effective thermal conductivity, thermal dispersion, thermal non equilibrium model (LTNE), transient heat conduction in porous media, Stokes flow and Darcy Equation, Hazen-Dupuit-Darcy (HDD) Model; High Reynolds number flows, macroscopic models, microscopic fluid dynamics; Brinkman model, Semi-Heuristic momentum equations, natural convection boundary layers: vertical and horizontal walls, natural convection with thermal gradient, non-Darcy, LTNE and heat generation effects, energy equation, forced convection in porous medium over a flat plate, forced convection in porous channel.

Course Outcomes

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

CO1: To Learn Fundamental Concept of Modelling of a Porous Medium.

CO2: To Learn the Fundamental Concept of Heat Conduction in Porous Medium.

CO3: To Learn the Fundamental Concept of Fluid Flow in Porous Medium.

CO4: To Learn the Fundamental Concept of Forced and Natural Convections in Porous.

Books and References

1. Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer, New York, 1999
2. Essential of Heat and Fluid Flow through Porous Media, by Arunn Narasimhan, Anne Books, New Delhi, 2013
3. Convection in Porous Media, by Nield, Donald A., Bejan, Adrian, Springer, 2013
4. Modeling Phenomena of Flow and Transport in Porous Media, by Jacob Bear, Springer, 2018

Micro and Nano Scale Heat Transfer

Course Code: ME-735 | Course Type: Program Elective

Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To provide a thorough understanding of heat transfer at micro and nano scales in microchannels
- To impart knowledge of the basic principles involved in the preparation and characterization of nano fluids

Course Content

Overview of length scales in heat transfer, importance of micro and nano-scale heat transfer in modern technology. thermal conductivity of nanostructured materials. thermal properties of nanowires, nanotubes, and nanoparticles. size effects in nanostructured materials, microstructure of solids, crystal vibrations and phonons, photon interactions, particle transport theories, non-equilibrium energy transfer, clusters and clustering, thermo-physical properties of clusters, control of clusters and condensation, thermodynamics of thin films, interfacial meniscus properties, interfacial mass flux, single phase and two phase flow, flow boiling, bubble behaviour, flow pattern, preparation of nano-fluids, sputtering, characterization of nano fluids, thermal properties of nano-fluids, single phase convective and boiling heat transfer processes.

Course Outcomes

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

CO1: Demonstrate a deep understanding of the fundamental principles governing heat transfer at the micro and nano scales.

CO2: Analyse heat transfer in nanostructures and identify unique heat transfer mechanisms at these scales.

CO3: Demonstrate a basic preparation of nanofluids, characterization of nanofluids, and thermal properties of nano-fluids.

Books and References

1. Tien, C. L., Majumdar, A. and Gerner, F. M., Microscale Energy Transport, Taylor & Francis, 1999
2. Zhang, Z., Nano/Microscale Heat Transfer, McGraw Hill, 2007
3. Volz, S., Microscale and Nanoscale Heat Transfer, Springer-Verlag, 2010
4. Celate, G. P., Heat Transfer and Transport Phenomena in Microscale, Begell House, 2000
5. Kakac, S., Vasiliev, L. L., Bayazitoglu, Y., Yener, Y., Microscale Heat Transfer: Fundamentals and Applications, Springer-Verlag, 2005
6. Sobhan, C. B. and Peterson, G. P., Microscale and Nanoscale Heat Transfer: Fundamentals and Engineering Applications, CRC Press, 2008

Thermal Managements of Electronics systems

Course Code: ME-701 Course Type: Institute Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To introduce Working principles, modelling, and design of thermal management systems for electronics.
- To discuss the hardware for thermal management of electronics for various applications.

Course Content

Importance and challenges of thermal management in electronic systems, overview of thermal management techniques and strategies, packaging and cooling technologies, trends and challenges, Active cooling methods (e.g., fans, pumps), passive cooling techniques (e.g., heat sinks, phase change materials), liquid cooling systems and heat pipes, thermal interface materials and thermal greases, heat transfer in extended surfaces, natural and forced convection, modelling and types of heat sinks, contact resistance and role of thermal interface materials, physical working principles of different types of heat pipes, wick based heat pipes, grooved heat pipes, micro heat pipes, looped heat pipes, mechanically pumped loops, Single phase and two-phase heat transfer, boiling regimes, effects of wettability, real-world examples of thermal management in electronic systems, design projects, or laboratory experiments related to thermal management, Industry applications, and best practices.

Course Outcomes

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

CO1: Explain the importance of thermal management in electronics and understand its significance in maintaining device performance.

CO2: Apply principles of heat transfer and fluid dynamics to design effective cooling solutions for electronic devices and systems.

CO3: Evaluate different cooling technologies and techniques, such as air cooling, liquid cooling, heat sinks, and phase-change materials.

Books and References

1. Y. Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press, 2009.
2. K. Azar, Thermal measurements in electronics cooling, CRC Press, 1997
3. S. Kakac, H. Yuncu, K. Hijikata, Cooling of Electronic Systems, Kluwer Academic Publishers.
4. D. Reay, P. Kew, R. McGlen, Heat Pipes: Theory, Design and Applications.
5. Butterworth Heinemann, 2014. J. Sergent, Thermal Management Handbook: For Electronic Assemblies, McGraw Hill Professional, 1998.
6. Lian-Tuu Yeh and R. C. Chu, Thermal Management of Microelectronic Equipment, ASME Press, 2002.

Measurement and Data Acquisition System

Course Code: ME-702 | Course Type: Institute Elective

Contact Hours/Week: 4L | Course Credits: 4

Course Objectives

- To understand the sensors transducer and signal conditioning techniques.
- To understand the data acquisition systems for sensor signal processing.

Course Content

Instrumentation systems, types of instrumentation systems, characteristics of instruments-static and dynamic, error analysis, components and uses of data acquisition systems, use of recorders, digital recording systems, multiplexer, sensors and transducers classification, Temperature, pressure, strain, flow, deflection, water level, motion, accelerometer, torque, variable resistance, capacitance, thermoelectric, photo-electric, piezo-electric type sensors for data acquisition, amplification, Operational amplifier, differential amplifier, adder, inverter, subtractor, integrator, differentiator, logarithmic converter, modulator, demodulators. types of filters, low pass, high pass, band pass, differentiating and integrating elements, resolution and quantization, aperture time, sampling, D/A Converters, A/D conversion techniques successive approximation resistor method, sample and hold circuit, analog multiplexer, terminology and conversions, data transmission elements, Indicating, recording and display elements, Introduction to microprocessors, IEEE 488 standard interface, –D-DAC, microprocessor based measurement, control and display of temperature, pressure, flow, speed, velocity, strain, etc.

Course Outcomes

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

CO1: Identify the required sensors and transducer for measurements.

CO2: Describe the use of Data Acquisition System from the system.

CO3: Apply Signal Conditioning and Signal Conversion Techniques

CO4: Assess the suitability of Data Acquisition for acquiring the signals from the sensor and transducer.

Books and References

1. Instrumentation, Measurement & Analysis, B.C Nakra & K.K Chaudhary, Tata McGraw Hill, 1985
2. Modern Control System Engineering, K.Ogata, Pearson Education, 5th Edition, 2010
3. Measurement System Applications and Design, E.O Doeblin, Tata- TMH, 5th Edition, 2007
4. Electronic measurement and instrumentation by Oliver & Cage,1971
5. Microcomputer Systems: The 8086/8088 family by YU-Cheng liu & Glenn A Gibson. Prentice Hall of India, 2nd Edition, 2004
6. Microprocessors with Applications in process Control by S.I. Ahson, Tata McGraw Hill New Delhi,1986

Optimisation Methods in Engineering

Course Code: ME-703 Course Type: Institute Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To formulate the design problems as mathematical programming problems.
- To determine the degree of attainment of the goals with the available resources.

Course Contents

Basic terminologies, design variables, objective function, constraints, objective function, variable bounds, problem formulation, and application of optimization methods in thermal engineering, optimality criteria; bracketing methods: exhaustive search method and bounding phase method; region-elimination methods: interval halving method, Fibonacci search method, and golden section search method; gradient-based methods: bisection method, newton-raphson method, and secant method, optimality criteria, unidirectional search, direct search methods: box method, Hooke-Jeeves pattern search method, Powell's conjugate direction method; gradient-based methods: cauchy's steepest descent method, newton's method, Marquardt's method, conjugate gradient method, and variable metric method, Kuhn-Tucker conditions, transformation methods: penalty function method, methods of multipliers, sensitivity analysis, integer programming: penalty function method, branch and bound method, geometric programming; non-traditional optimization algorithms: genetic algorithms, simulated annealing

Course Outcomes

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

CO1: Identify the required techniques to achieve a desired set of objectives.

CO2: Describe the best satisfying solution under a varying amount of resources and priorities of the goals.

CO3: Apply principles of resource optimization

CO4: Assess the suitability of technique for optimizing the real world problem

Books and References

1. Optimization for Engineering Design: Algorithms and Examples by Kalyanmoy Deb, PHI Publication, 2012
2. Engineering Optimization: Theory and Practice by S.S Rao, New International (P) Publication.3rd Edition 2013
3. Engineering Optimization - Methods and Applications by Ravindran, Ragsdell and Rekla, John Wiley & Sons Publication, 2006
4. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley Publication. 2001

Soft Computing Methods in Engineering

Course Code: ME-704 Course Type: Institute Elective

Contact Hours/Week: 4L Course Credits: 4

Course Objectives

- To cover fundamental concepts used in soft computing.
- To understand concepts of Fuzzy Logic (FL) and Artificial Neural Networks (ANNs) and optimization techniques using Genetic Algorithm (GA).

Course Content

Need and classification of soft computing methods, soft computing vs. hard computing, applications of soft computing, artificial neural networks**,** characteristics, learning methods, taxonomy, evolution of neural networks, basic models,, important technologies, applications, single layer perceptron's, multi-1 feed-forward neural networks, learning processes, radial basis function networks, recurrent networks, principal component analysis; applications of ann in engineering, fuzzy set theory, fuzzy versus crisp set, fuzzy relation, fuzzification, min-max composition, defuzzification method, fuzzy logic, fuzzy rule based systems, predicate logic, fuzzy decision making, genetic algorithm and search space, general genetic algorithm, operators, generational cycle, stopping condition, constraints, classification, genetic programming, multilevel optimization, real life problem, combined techniques – genetic algorithms–fuzzy logic, genetic algorithms–neural networks, neural networks– fuzzy logic.

Course Outcomes

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

CO1: Identify the idea of conceptual intelligence in machines.

CO2: Describe the reasoning, thinking, analysing and detecting that correlates the real-world problems to the technically inspired methods.

CO3: Apply principles of extension of Heuristics: Neural Networking, Fuzzy Logics and Genetic Algorithm.

Text Books & References:

1. Neural Networks: A Comprehensive Foundation by S. Haykin, Pearson, 2nd Edition, 2007
2. Fuzzy Logic with Engineering Application by T. J. Ross, John Wiley and Sons, 4th Edition, 2016
3. Evolutionary Computation by D.B. Fogel, IEEE Press, 1995
4. Genetic Algorithms: Search and Optimization, E. Goldberg, 1989
5. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PHI, 1996
6. Build_Neural_Network_With_MS_Excel_sample by Joe Choong, 2009