

UNIVERSITY OF ENGINEERING AND MANAGEMENT, JAIPUR

M.Tech Thermal Engineering 1st year (1st semester)

Title of Course: Advanced Heat and Mass Transfer

Course Code: TE101

L-T-P Scheme: 3-1-0

Course Credits: 4

Introduction:

Heat transfer and mass transfer are kinetic processes that may occur and be studied separately or jointly. Studying them apart is simpler, but both processes are modelled by similar mathematical equations in the case of diffusion and convection (there is no mass-transfer similarity to heat radiation), and it is thus more efficient to consider them jointly. Besides, heat and mass transfer must be jointly considered in some cases like evaporative cooling and ablation. The usual way to make the best of both approaches is to first consider heat transfer without mass transfer, and present at a later stage a briefing of similarities and differences between heat transfer and mass transfer, with some specific examples of mass transfer applications.

Course Objectives:

The objectives of this subject are as follows:

1. To develop the fundamental principles and laws of heat transfer and to explore the implications of these principles for system behavior.
2. To formulate the models necessary to study, analyze and design heat transfer systems through the application of these principles.
3. To develop the problem-solving skills essential to good engineering practice of heat transfer in real-world applications.

Learning Outcomes:

Upon completion of this course, the Students will:

1. Have a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.
2. Be able to design, analyze, and test “intelligent” products and processes that incorporate appropriate computing tools, sensors, and actuators.
3. Be able to demonstrate professional interaction and communicate effectively with team members.
4. Be able to work efficiently in multidisciplinary teams.
5. Be prepared for a variety of engineering careers, graduate studies, and continuing education
6. Practice professional and ethical responsibility, and, be aware of the impact of their designs on human-kind and the environment.

Course Contents:

Review : Review of the basic laws of conduction, radiation and convection.

Conduction : One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source; local heat source in non adiabatic plate. Extended surfaces-review; optimum fin of rectangular profile; straight fins of triangular and parabolic profiles; optimum profile; circumferential fin of rectangular profile; spines; design considerations. Two dimensional steady state conduction; semi-infinite and finite flat plates temperature field in finite cylinders and in infinite semi cylinders. Unsteady state

conduction; sudden changes in the surface temperatures of infinite plate, cylinders and spheres; solutions using Groeber's and Heisler's charts for plates, cylinders and spheres suddenly immersed in fluids.

Radiation : Review of radiation principles; diffuse surfaces and the Lambert's Cosine law. Radiation through non-absorbing media; Hottel's method of successive reflections.

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Radiation : Review of radiation principles; diffuse surfaces and the Lambert's Cosine law. Radiation through non-absorbing media; Hottel's method of successive reflections.

TEXT BOOKS:

1. YunusA.Cengal, Heat and Mass Transfer – A practical Approach, 3rd edition, Tata McGraw - Hill, 2007.
2. Holman.J.P, Heat Transfer, Tata Mc Graw Hill, 2002.
3. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985
4. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 2002.
5. Nag.P.K, Heat Transfer, Tata McGraw-Hill, 2002
6. Ghoshdastidar. P.S., Heat Transfer, Oxford University Press, 2004
7. Yadav, R., Heat and Mass Transfer, Central Publishing House, 1995.

Title of Course : Advanced Thermodynamics**Course Code: TE102****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

This course will prepare post graduate level engineering students to effectively solve theoretical and applied thermodynamics problems that are directly applicable to situations faced in research and industry. Significant emphasis is placed on the integration of recent thermodynamics-related research into the traditional resources in order to foster critical analysis of current work as it relates to fundamental principles. Multiple forms of assessment will be used throughout the course in order to evaluate student learning. As this is a post graduate-level course, many of the competency-based assessments can be tailored to be useful to your long-term learning goals. In addition, multiple professional skills will be practiced and demonstrated throughout the course, such as engineering communication and teamwork, since these skills are important in all engineering professions.

Course Objectives:

The objectives of this subject are as follows:

1. Apply first and second law analysis to opened and closed systems;
2. Understand the key postulates to thermodynamics and their relationship to equilibrium and properties;
3. Understand and apply the fundamental relation, the Euler equation and the Gibb-Duhem relation; 4. Apply equations of state to make property calculations of real gases;
5. Apply relations between thermodynamic properties (Maxwell relations);
6. Analyze multicomponent & multiphase systems, phase equilibrium; and chemical reactions.

Learning Outcomes:

By the end of this course, students will be able to:

1. Describe and calculate thermodynamic properties of single-phase and multi-phase systems
2. Apply the laws of statistical and classical thermodynamics to chemically reactive systems, kinetics, and combustion.
3. Relate course principles to solve problems regarding gas turbines, combustion, refrigeration, and solar energy.
4. Communicate engineering knowledge of thermodynamics through written and verbal means.

Course Contents:

Review of basic thermodynamic principles; entropy; availability; irreversibility; first and second law analysis of steady and unsteady systems;

General thermodynamics relations; Fundamentals of partial derivatives; relations for specific heats; internal energy enthalpy and entropy; Joule - Thompson coefficient; Clapeyron equation.

Multi component systems; Review of equation of state for ideal and real gases; thermodynamic surfaces; gaseous mixtures; fugacity; ideal solutions; dilute solutions; activity; non ideal liquid solutions.

Multi component phase equilibrium ; Criteria of equilibrium; stability; heterogeneous equilibrium; binary vapour liquid systems; the nucleus of condensation and the behaviour of stream with formation of large and small drops; Gibbs Phase rule; higher order phase transitions.

Thermodynamics of chemical reaction (combustion); internal energy and enthalpy - first law analysis and second law analysis; basic relations involving partial pressures; third law of thermodynamics; chemical equilibrium and chemical potential equilibrium constants; thermodynamics of low temperature.

Statistical mechanics - Maxwell - Boltzmann statistics; microstate and macrostates; thermodynamic probability; entropy and probability Bose Einstein statistics; Fermi Dirac statistics.

Elementary concepts of irreversible thermodynamics

TEXT BOOKS:

1. Basic and Applied Thermodynamics, P.K.Nag, TMH
2. Element of Gas Dynamics, Yahya, TMH
3. Fluid Mechanics and Machines, Modi and Seth, Standard Book House
4. Thermodynamics, Sonntag & Van Wylen, John Wiley & Sons
5. Thermodynamics for Engineers, Doolittle-Messe , John Wiley & Sons
6. Heat Transfer,P.K.Nag,TMH

Title of Course : Advanced Fluid Mechanics**Course Code: TE103****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

The subject is to introduce the students to advanced fluid dynamics calculations : two- and three-dimensional flows, analytical theory, graphical methods and computations. Subject goals: Ideal-fluid flow calculations may provide analytical solutions of simple fluid dynamics problems. Engineering applications include groundwater flow, spillway intake, airfoils, dispersion in rivers. The concepts of streamlines and equi-potentials are derived from the basic principles of fluid mechanics (continuity, Bernoulli, momentum) and a graphical method is developed. The students are exposed to engineering applications and learn to distinguish between ideal-fluid and real-fluid flows. Real fluid flow situations are analysed, including boundary layer flow, dispersion of matter and fluid-structure interactions.

Course Objectives:

The objectives of this subject are as follows:

1. To understanding basic laws, principles and phenomena in the area of fluid mechanics –
2. To solve simplified examples of fluid mechanics –
3. Theoretical and practical preparation enabling students to apply the acquired knowledge and skills in professional and specialist courses

Learning Outcomes:

1. Define basic terms, values and laws in the areas of fluids properties, statics, kinematics and dynamics of fluids, and hydraulic design of pipes,
2. Describe methods of implementing fluid mechanics laws and phenomena while analysing the operational parameters of hydraulic problems, systems and machines,
3. Practically apply tables and diagrams, and equations that define the associated laws
4. Calculate and optimise operational parameters of hydraulic problems, systems and machines,
5. Explain the correlation between different operational parameters,
6. Select engineering approach to problem solving based on the acquired physics and mathematical knowledge.

Course Contents:

Basic Equations ;

Deformation and the rate of strain, the deformation tensor, skew-symmetry of the deformation tensor, symmetry of the stress tensor, polar and non-polar fluids, stokesian and Newtonian fluids. Derivation of the general differential equations of continuity, momentum and energy in vector form; Euler and Navier-Stokes equations, integration of the momentum equation; the generalized Bernoulli's equation.

Two Dimensional Irrotational Flow:

Two dimensional flow in rectangular and polar coordinates; continuity equation and the stream function, irrotationality and the velocity potential function, vorticity and circulation, plane potential flow and the complex potential function. Sources, sinks, doublets and vortices; superposition of uniform stream with above; flow around corners; Rankine ovals, flow around circular cylinders with the without circulation, pressure distribution on the surface of these bodies. Elements of two dimensional aerofoils theory, symmetrical aerofoil theory; lift and moment.

Vortex Motion:

Definitions, vortex lines, surfaces and tubes, vorticity, circulation; Kelvin's circulation theorem, Helmholtz's vorticity theorems; the convection and diffusion of vorticity.

Viscous Flow:

Exact solution, plane Poiseuille and Couette flows; Hagen Poiseuille flow through pipes. Flows with very small Reynolds number. Flows with very large Reynolds number, elements of two dimensional boundary layer theory; displacement thickness and momentum thickness, skin friction, Blasius solution for boundary layer on a flat plate without pressure gradient; the Karman-Polhausen integral method for obtaining approximate solutions. Drag on bodies; form drag and skin friction drag profile drag and its measurement

TEXT BOOKS:

1. Massey, Mechanics of Fluids, Taylor & Francis.
2. M.M. Das, Fluid mechanics and turbo machines, PHI.
3. S.K. Som & G. Biswas, Introduction to Fluid Mechanics & Fluid Machines, TMH. REFERENCES:
4. Fox & McDonald, Introduction to Fluid Mechanics, Wiley.
5. Bansal, Fluid Mechanics and Machinery, Laxmi.
6. C.S.P. Ojha, R. Berndtsson, P.N. Chandramouli, Fluid Mechanics & Machinery, Oxford University Press.

Title of Course : Applied Mathematics for Mechanical Engineers

Course Code: TE104

L-T-P Scheme: 3-1-0

Course Credits: 4

Introduction:

This course offers an advanced introduction to numerical linear algebra. Topics include direct and iterative methods for linear systems, eigenvalue decompositions and QR/SVD factorizations, stability and accuracy of numerical algorithms, the IEEE floating point standard, sparse and structured matrices, preconditioning and linear algebra software. Problem sets require some knowledge of MATLAB

Course Objectives:

The course is intended to cover, basics concepts of mathematics like numerical algebra, probability , simulations specially Monte- Carlo simulations which will help in understanding theoretical concepts of Nanotechnology.

Learning Outcomes:

- 1.To know the importance of simulations in nanotechnology.
2. Students without mathematics back ground will be able to understand the concept of mathematics.
- 3.To evaluate nanostructured simulations in nanotechnology

Course Contents:

Numerics in general: Interpolation, Gauss elimination, Solution by iteration, least square method.

Numeric Linear Algebra and differential equations: Matrix Eigen value problems: Introduction, Inclusion of Matrix Eigen values, Tridiagonalization and RQ factorization. Methods for first order ODEs, Multi step methods, Higher order ODES

Introduction to probability: Probability, Sample space and events- Probability- the axioms of probability, some elementary theorems-conditional probability Baye's theorem Random Variables Discrete and continuous – distribution- distribution function Distribution Binomial and poison distributions and normal distribution – related properties.

Systems, Models, Simulations and the Monte Carlo Methods: Systems,Models,Simulation and the Monte Carlo Methods, Random number generation, Introduction, Congruential Generators, Statistical Tests of Pseudorandom Numbers, Random variate generation, inverse Transform Method, Composition Method, Acceptance-Rejection Method,

Monte Carlo integration and Variance reduction techniques: Introduction, Monte Carlo Integration, The Hit or Miss Monte Carlo Method, The Sample-Mean Monte Carlo Method, Efficiency of Monte Carlo Method, Integration in Presence of Noise,

TEXT BOOKS:

1. Advanced engineering mathematics, by Erwin Kreyszig, wiley publications
2. Probability and statistics, scham series, Arnold o. allen, academic press
3. Probability and statistics, Arnold o. allen, academic press
4. Probability and statistics for engineers, miller and john e. freund, prentice hall of india
5. A primer for the monte carlo method, Ilya M. Sobol' CRC Press

Title of Course : Thermal Engineering Lab**Course Code: TE191****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

Heat Transfer laboratory provides fundamental and industrial knowledge about modes of heat transfer, like conduction, convection and radiation, and their application.

Heat Transfer is one of the important subjects which is commonly applied in renewable energy, industrial, commercial and domestic systems. The experiments are designed to provide exposure of practical aspects of the various theoretical concepts developed under the course, Heat and Mass Transfer. The laboratory consists of experiments on various conductive, convective, radiative, boiling and condensing mechanisms of heat transfer.

Objective:

1. To understanding basic laws, principles and phenomena in the area of thermal engineering
2. To solve simplified examples of thermal engineering
3. Theoretical and practical preparation enabling students to apply the acquired knowledge and skills in professional and specialist courses

Learning Outcomes:

At the successful completion of course, the student is able to:

1. Practically relate to concepts discussed in the Heat Transfer course.
2. Conduct various experiments to determine thermal conductivity and heat transfer coefficient in various materials.
3. Select appropriate materials & designs for improving effectiveness of heat transfer.
4. Conduct performance tests and thereby improve effectiveness of heat exchangers.
5. Conduct performance tests and thereby improve effectiveness of refrigeration and air conditioning systems.

Course Contents:

1. Performance analysis of four stroke S.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance.
2. Performance analysis of four stroke C.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance.
3. Performance analysis of an alternate fuel on computerized IC Engine test rig.
4. Calculation of thermal conductivity of metal rods.
5. Experiment on Pin fin Apparatus (free and forced convection heat transfer).
6. COP calculation on air conditioning test rig apparatus.
7. COP calculation on simple vapour compression refrigeration test rig.
8. Performance test and analysis of exhaust gases of an I.C. Engine.
9. Dryness fraction estimation of steam
10. Compressibility factor measurement of different real gases.

M.Tech Thermal Engineering 1st year (2nd semester)

Title of Course: Computational Fluid Dynamics

Course Code: TE201

L-T-P Scheme: 3-1-0

Course Credits: 4

Introduction:

Computational fluid dynamics (CFD) has become an essential tool in analysis and design of thermal and fluid flow systems in wide range of industries. Few prominent areas of applications of CFD include meteorology, transport systems (aerospace, automobile, highspeed trains), energy systems, environment, electronics, bio-medical (design of lifesupport and drug delivery systems), etc. The correct use of CFD as a design analysis or diagnostic tool requires a thorough understanding of underlying physics, mathematical modeling and numerical techniques. The user must be fully aware of the properties and limitations of the numerical techniques incorporated in CFD software. This course aims to provide precisely these insights of CFD

Course Objective:

Specific objectives may be summarized as:

1. To understand mathematical characteristics of partial differential equations.
2. To understand basic properties of computational methods – accuracy, stability, consistency
3. To learn computational solution techniques for time integration of ordinary differential equations
4. To learn computational solution techniques for various types of partial differential equations
5. To learn how to computationally solve Euler and Navier-Stokes equations
6. To acquire basic programming and graphic skills to conduct the flow field calculations and data analysis.

Learning Outcomes:

After studying this course, students will be able to:

1. Differentiate the FDM, FVM and FEM
2. Perform the flow, structural and thermal analysis.
3. Utilize the discretization methods according to the application.

Course Contents:

INTRODUCTION: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions, Derivation of finite difference equations. Solution methods: Solution methods of elliptical equations — finite difference formulations, interactive solution methods, direct method with Gaussian elimination. Parabolic equations-explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

Hyperbolic equations: explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods. Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

FINITE VOLUME METHOD: Finite volume method via finite difference method, formulations for two and three-dimensional problems. **STANDARD VARIATIONAL METHODS:** Linear fluid flow problems, steady state problems, Transient problems.

TEXT BOOKS:

1. Computational fluid dynamics T. J. C'hung Cambridge University press, 2002.
2. Text book of fluid dynamics Frank Choriton CBS Publishers & distributors, 1985
3. Numerical heat transfer and fluid flow Suhas V. Patankar Hema shava Publishers corporation & Mc Graw Hill.
4. Computational Fluid Flow and Heat Transfer Muralidaran Narosa Publications
5. Computational Fluid Dynamics: Basics with applications John D. Anderson Mc Graw Hill.

Title of Course: Thermal and Nuclear Power Plant**Course Code: TE202****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

The nuclear power plant and the fossil thermal power plant both use steam to convert the heat or thermal energy to mechanical rotation to rotate the generator to produce electricity. Only the heat source is different. In a nuclear plant, the heat source is from the nuclear reaction whereas in a thermal power plant it is from the combustion of coal.

The difference is in the inlet steam parameters to the turbine in a nuclear plant. Thermal power plants use steam at superheated conditions. In nuclear plants, the steam is at saturated conditions and at a lower pressure. This is due to the inherent design limitations in the nuclear reactors.

Course Objectives:

To make the student understand

1. various improvements possible in steam and gas turbines
2. advanced power cycles
3. advances in nuclear and MHD power plants.
4. combined operations of different power plants
5. environmental issues related to the power plants.
6. economic analysis of power plants

Learning Outcomes:

The student will be able to

1. suggest improvements possible in steam and gas turbines
2. advanced power cycles
3. explain advances in nuclear and MHD power plants
4. explain how to combine different power plants
5. handle issues related to the power plants

Course Contents:

INTRODUCTION: Sources of energy, Type of Power plants. Direct energy conversion system, Energy sources in India, Recent developments in power generation, Combustion of coal, Volumetric analysis, Gravimetric analysis. Fuel gas analysis.

Steam power plant: Introduction. General layout of steam power plant, Modern coal. Fired Steam, Steam power plant. Power plant cycle, Fuel Handling, Combustion equipment, Ash handling, Dust collectors. Steam Generators: Types, Accessories. Feed water heaters, Performance of boiling, Water treatment, Cooling towers. Steam turbines. Compounding of turbines, Steam condensers, Jet and surface condensers.

GAS TURBINE POWER PLANT: Cogeneration. Combined cycle power plant, Analysis, Waste heat recovery, IGCC power plant, Fluidized bed, Combustion, Advantages, Disadvantages.

NUCLEAR POWER PLANT: Nuclear physics, Nuclear Reactor, Classification, Types of reactors, Site selection. Method of enriching uranium. Application of nuclear power plant. Nuclear Power Plant Safety: Bi-Product of nuclear power generation, Economics of nuclear power plant, Nuclear power plant in India, Future of nuclear power.

ECONOMICS OF POWER GENERATION: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, Point economic load sharing, Depreciation. Energy rate, Criteria for optimum loading. Specific economic energy problem.

POWER PLANT INSTRUMENTATIONS: Classification, Pressure measuring instrument, Temperature measurement and Flow Measurement, Analysis of combustion gases, Pollution types, Methods of control.

TEXT BOOKS:

1. Power Plant Engineering P.K.Naga TMH
2. Power Plant Engineering R.K.Rajput Lakshmi Publications.
3. Power Plant Engineering P.C.SharmaKotearia Publications.
4. Power Plant Technology Wakil.

Title of Course: Simulation, Modelling & Analysis**Course Code: TE203****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

The course will introduce the basic concepts of computation through modeling and simulation that are increasingly being used by architects, planners, and engineers to shorten design cycles, innovate new products, and evaluate designs and simulate the impacts of alternative approaches. Students will use MATLAB to explore a range of programming and modeling concepts while acquiring those skills. They will then undertake a final project that analyzes one of a variety of scientific problems by designing a representative model, implementing the model, completing a verification and validation process of the model, reporting on the model in oral and written form, and changing the model to reflect corrections, improvements and enhancements.

Course Objectives:

- Introduce computer simulation technologies and techniques, provides the foundations for the student to understand computer simulation needs, and to implement and test a variety of simulation and data analysis libraries and programs. This course focusses what is needed to build simulation software environments, and not just building simulations using preexisting packages.
- Introduce concepts of modeling layers of society's critical infrastructure networks.
- Build tools to view and control simulations and their results.

Learning Outcomes:

1. Demonstrate basic programming skills – functions, arrays, loops, conditional statements, procedures
Explain the Role of Modeling: Discuss the importance of modeling to science and engineering
2. define the terms associated with modeling to science and engineering
3. list questions that would check/validate model results

Course Contents:

Introduction: Simulation: a tool, advantages and disadvantages of simulation, areas of application, systems and system environment, components of a system, discrete and continuous systems, discrete event system simulation. General Principles: Concepts in discrete event simulation, time advance algorithm, manual simulation using event scheduling, basis properties and operations.

Models In Simulation: Terminology and concepts, statistical models: queuing systems; inventory systems; reliability and maintainability, limited data, discrete distributions: Bernoulli distribution; Binomial distribution; Geometric distribution, continuous distribution: Uniform distribution; Exponential distribution; Gamma distribution; Normal distribution; Weibull distribution; Triangular Distribution; Lognormal distribution, poisson process

Queueing Models: Characteristics of queuing systems, the calling population, system capacity, arrival process, service mechanism, queuing notations, long run measures of performance of queuing systems, server utilization in $G/G/1/\infty/\infty$ queues, server utilization in $G/G/C/\infty/\infty$ queues, server utilization and system performance, costs in queuing problems, Larkovian models.

Random Number Generation: Properties of random numbers, Pseudo random numbers, techniques of generating random numbers, tests of random numbers. Random Variate Generation: Inverse transform technique, Direct transformation for the Normal and Lognormal distribution, Convolution Method, Acceptance rejection technique.

Input Modelling And Validation: Steps in the development of model, data collection, Distribution identification, Parameter estimation, Goodness of Fit Tests, selecting input models without data, verification and validation of simulation models.

TEXT BOOKS:

1. Simulation Modelling and Analysis by Law and Kelton, Mc Graw Hill.
2. Simulation Model Design & execution by Fishwick, Prentice Hall.
3. Discrete event system simulation by Banks, Carson, Nelson and Nicol.

Title of Course: Solar Energy Technology**Course Code: TE204****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

In this course, you will learn about the fundamentals of photoelectric conversion: charge excitation, conduction, separation, and collection. You will become familiar with commercial and emerging photovoltaic (PV) technologies and various cross-cutting themes in PV: conversion efficiencies, loss mechanisms, characterization, manufacturing, systems, reliability, life-cycle analysis, and risk analysis. Other topics covered include photovoltaic technology evolution in the context of markets, policies, society, and environment.

Course Objectives:

By the year 2030, several hundred gigawatts of power must be generated from low-carbon sources to cap atmospheric CO₂ concentrations at levels deemed "lower-risk" by the current scientific consensus. The necessity to develop low-carbon energy sources represents not only an awesome technological and engineering challenge, but also an equally large economic opportunity in a trillion-dollar energy market. Students will learn how solar cells convert light into electricity, how solar cells are manufactured, how solar cells are evaluated, what technologies are currently on the market, and how to evaluate the risk and potential of existing and emerging solar cell technologies. We examine the potential & drawbacks of currently manufactured technologies (single- and multicrystalline silicon, CdTe, CIGS, CPV), as well as pre-commercial technologies (organics, biomimetic, organic / inorganic hybrid, and nanostructure-based solar cells). Hands-on laboratory sessions explore how a solar cell works in practice. We will learn how to enhance solar cell performance and reduce cost, and the major hurdles—technological, economic, and political—towards widespread adoption. Students will apply this knowledge towards developing a class project on the solar-related topic of their choosing.

Learning Outcomes:

On completion of the course, the student should be able to:

1. explain the technical and physical principles of solar cells,
2. measure and evaluate different solar cell technologies and relate these to underlying theory,
3. calculate the required size of solar cell systems from a given power demand by using appropriate calculations and simulation software,
4. communicate technical and socioeconomic issues of solar energy in a concise and comprehensible way by using poster presentations, Power Point or similar, in English.

Course Contents:

Introduction – Solar energy option, specialty and potential – Sun – Earth – Solar radiation, beam and diffuse – measurement – estimation of average solar radiation on horizontal and tilted surfaces – problems – applications. Capturing solar radiation – physical principles of collection – types – liquid flat plate collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors – cylindrical parabolic collectors – Orientation and tracking – Performance Analysis.

DESIGN OF SOLAR WATER HEATING SYSTEM AND LAYOUT: Power generation – solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system –

Power cycles, working fluids and prime movers, concentration ratio. THERMAL ENERGY STORAGE: Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle – construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

DIRECT ENERGY CONVERSION: solid-state principles – semiconductors – solar cells – performance – modular construction – applications. conversion efficiencies calculations.

ECONOMICS: Principles of Economic Analysis – Discounted cash flow – Solar system – life cycle costs – cost benefit analysis and optimization – cost based analysis of water heating and photo voltaic applications.

TEXT BOOKS:

1. Principles of solar engineering Kreith and Kerider Taylor and Francis 2nd edition
2. Solar energy thermal processes Duffie and Beckman John Wiley & Sons
3. Solar energy: Principles of Thermal Collection and Storage/ Sukhatme TMH 2nd edition

Title of Course : Simulation Modeling & Analysis Lab

Course Code: TE291

L-T-P Scheme: 3-1-0

Course Credits: 4

Introduction:

Modeling and Simulation (IM/S) provides an introduction into modeling and simulation approaches, covering continuum methods (e.g. finite element analysis), atomistic simulation (e.g. molecular dynamics) as well as quantum mechanics. Atomistic and molecular simulation methods are new tools that allow one to predict functional material properties such as Young's modulus, strength, thermal properties, color, and others directly from the chemical makeup of the material by solving Schroedinger's equation (quantum mechanics). This approach is an exciting new paradigm that allows to design materials and structures from the bottom up — to make materials greener, lighter, stronger, more energy efficient, less expensive; and to produce them from abundant building blocks. These tools play an increasingly important role in modern engineering! In this subject you will get hands-on training in both the fundamentals and applications of these exciting new methods to key engineering problems.

Objective:

- Introduce computer simulation technologies and techniques, provides the foundations for the student to understand computer simulation needs, and to implement and test a variety of simulation and data analysis libraries and programs. This course focusses what is needed to build simulation software environments, and not just building simulations using preexisting packages.
- Introduce concepts of modeling layers of society's critical infrastructure networks.
- Build tools to view and control simulations and their results.

Learning Outcomes:

Upon completion of this course, the Students can demonstrate different measurement technologies and use of them in Industrial Components

Course Contents:

1. Study of simulation software Like ARENA , MATLAB.
2. Simulation of translational and rotational mechanical systems
3. Simulation of Queuing systems
4. Simulation of Manufacturing System
5. Generation of Random number
6. Modeling and Analysis of Dynamic Systems
7. Simulation mass spring damper system
8. Simulation of hydraulic and pneumatic systems.
9. Simulation of Job shop with material handling and Flexible manufacturing systems
10. Simulation of Service Operations

M.Tech Thermal Engineering 2nd year (3rd semester)

Title of Course : Optimization Techniques & Design Of Experiments

Course Code: TE301

L-T-P Scheme: 3-1-0

Course Credits: 4

Introduction:

This course introduces students to concepts and techniques of Classical and Bayesian design - experimental units, randomization, treatments, blocking and restrictions to randomization, and utility of designs. We will cover optimal sample size determination for estimation and testing. Topics include simple A-B testing, factorial and fractional factorial designs, response surface methods, conjoint designs, sequential designs, bandit problems used in on-line advertising, design and modeling of complex computer experiments, and designs for multiple objectives. Computational algorithms for finding optimal designs will be covered in the context of various problems.

Course Objective:

1. Understanding the details of various design methods,
2. Being able to use one or more appropriate techniques to analyze experimental results

Learning Outcomes:

1. Understand the different philosophical approaches to experimental design (Bayesian and frequentists)
2. Build a solid foundation for the statistical theory for experimental design.
3. Build appropriate statistical models for designed experiments, perform data analysis using appropriate software, and communicate results without use of statistical jargon.
4. Construct appropriate experimental designs for given problems: sample size determination, choice of levels of variables, designs with restrictions on randomization, utility functions for measuring design objectives, use of simulation to characterize properties of designs

Course Contents:

SINGLE VARIABLE NON-LINEAR UNCONSTRAINED OPTIMIZATION: One dimensional Optimization methods, Uni-modal function, elimination method, Fibonacci method, golden section method, interpolation methods- quadratic & cubic interpolation methods.

MULTI VARIABLE NON-LINEAR UNCONSTRAINED OPTIMIZATION: Direct search method – Univariate Method – pattern search methods – Powell's – Hook – Jeeves, Rosenbrock search methods – gradient methods, gradient of function, steepest decent method, Fletcher reeves method. Variable metric method.

GEOMETRIC PROGRAMMING: Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P

DYNAMIC PROGRAMMING: Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

LINEAR PROGRAMMING: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Simulation: Introduction – Types – Steps – application – inventory – queuing – thermal system.

INTEGER PROGRAMMING: Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.

STOCHASTIC PROGRAMMING: Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

TEXT BOOKS:

1. Optimization theory & Applications S.S Rao New Age International
2. Introductory to operation research K. S. Nigam & Kumar Springar
3. Optimization Techniques theory and practice M.C Joshi, K.M Moudgalya Narosa Publications.
4. Operation Research H.A. Taha TMH
5. Optimization in operations research R.L Rardin

Title of Course : Theory and Design of Heat Exchangers**Course Code: TE302****L-T-P Scheme: 3-1-0****Course Credits: 4****Introduction:**

The heat exchanger design equation can be used to calculate the required heat transfer surface area for a variety of specified fluids, inlet and outlet temperatures and types and configurations of heat exchangers, including counterflow or parallel flow. A value is needed for the overall heat transfer coefficient for the given heat exchanger, fluids, and temperatures. Heat exchanger calculations could be made for the required heat transfer area, or the rate of heat transfer for a heat exchanger of given area.

Course Objectives:

To learn the sizing of heat exchangers, thermal and mechanical stress analysis for various heat exchange applications

Learning Outcomes:

After learning the course, the students should be able to:

1. Learn how to design common types of heat exchangers; namely shell-and-tube, tube and tube.
2. Demonstrate a basic understanding of several types of heat exchangers that will include shell-andtube, double pipe, finned tube, and plate-fin heat exchangers and learn to select appropriate heat exchanger for the given application
3. Measure the performance degradation of heat exchangers subject to fouling.
4. Become aware of single and multiphase heat transfer and friction coefficient correlations, and they will know how to select the appropriate ones for the case in hand

Course Contents:

Different classification and basic design methodologies for heat exchanger:

Classification of heat exchanger, selection of heat exchanger, overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multi-pass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, fouling, cleanliness factor, percent over surface, techniques to control fouling, additives, rating and sizing problems, heat exchanger design methodology

Design of double pipe heat exchangers:

Thermal and hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop

Design of Shell & tube heat exchangers:

Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.

Transfer Enhancement and Performance Evaluation:

Enhancement of heat transfer, Performance evaluation of Heat Transfer Enhancement technique.

Introduction to pinch analysis

Design of compact heat exchangers

Heat transfer enhancement, plate fin heat exchanger, tube fin heat exchanger, heat transfer and pressure drop

TEXT BOOKS:

1. T.Taborek, G.F.Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw-Hill Book Co.1980.
 2. Walker, Industrial Heat Exchangers- A Basic Guide, Mc Graw Hill Book Co. 1980
 3. Nicholas Cheremistoff, Cooling Tower, Ann Arbor Science Pub 1981
 4. Arthur, P. Frass, Heat Exchanger Design, John Wiley and Sons, 1988
 5. J.P. Gupta, Fundamentals of heat exchangers and pressure vessel technology, Hemisphere publishing corporation, Springer-Verlag (outside NA), 1986
 6. Donald Q. Kern and Alban D. Kraus, "Extended surface hear transfer" Mc Graw Hill Book Co., 1972
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