Curriculum Structure and Syllabus

for

M.Tech.

in

Mechanical Engineering

Specialization with
Thermal Engineering
A.Y 2020-2021

Department of Mechanical Engineering
National Institute of Technology Andhra Pradesh
Tadepalligudem, West Godavari Dist., 534 101
Andhra Pradesh

Curriculum Structure and Syllabus
For M. Tech. in Mechanical Engineering
Specialization: Thermal Engineering
For the Academic Year 2018-19 admitted batch

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Course structure

Distribution of Total Credits:

Semester	Core subjects	Dept. Elective	Open * Elective	Labs.	Seminar	Comp. viva	Dissertation-Part A	Dissertation-Part B	Total
I	4 (4*4=16)	1 (1*3=3)	---	1 (1*2=2)	-	-	-	-	**21**
II	2 (2*4=8)	2 (2*3=6)	1 (1*3=3)	1 (1*2=2)	1 (1*2=2)	-	-	-	**21**
III	-	2 (2*2=2) Elective from MOOCS		-	-	2	8 (equivalent to 2 core subjects)	-	**14**
IV	-	-	-	-	-	-	-	16 (equivalent to 4 core subjects)	**16**
Total									**72**

COURSE STRUCTURE & SCHEME OF INSTRUCTION

I –Semester

Code No.	Subject Name	L-T-P	Cr.
19PME1-C101	Advanced Thermodynamics	4-0-0	4
19PME1-C102	Advanced Heat & Mass Transfer	4-0-0	4
19PME1-C103	Advanced Prime Movers	4-0-0	4
19PME1-C104	Numerical Methods in Thermal Engineering	4-0-0	4
19PME1-E1--	Department Elective – I	3-0-0	3
19PME1-L101	Thermal Engineering Laboratory	0-0-3	2
Total			**21**

II -Semester

Code No.	Subject Name	L-T-P	Cr.
19PME1-C201	Gas Turbines and Jet Propulsion	4-0-0	4
19PME1-C202	Computational Methods in Fluid Flow and Heat Transfer	4-0-0	4
19PME1-E2--	Department Elective – II	3-0-0	3
19PME1-E2--	Department Elective – III	3-0-0	3
19PME – OE--	Open Elective – I	3-0-0	3
19PME1-S201	Seminar	0-0-3	2
19PME1-L201	CFD Laboratory	0-0-3	2
Total			**21**

III –Semester

Code No.	Subject Name	L-T-P	Cr.
	Mandatory Elective from Coursera /NPTEL/SWAYAM/MIT		2
	Mandatory Elective from Coursera /NPTEL/SWAYAM/MIT		2
	Comprehensive Viva		2
	Dissertation-Part A		8
Total			**14**

IV –Semester

Code No.	Subject Name	L-T-P	Cr.
	Dissertation-Part B		16
Total			**16**

*The student can register for two numbers of online courses at any point of time since their admission. However, the course completion cum pass certificates shall be submitted by the end of third semester for fulfilling the curriculum.

LIST OF ELECTIVES

Semester – I

Course Code	Course Title
19PME1-E101	Incompressible and Compressible Flows
19PME1-E102	Heating, Ventilating, and Air-conditioning
19PME1-E103	Alternate Fuels and Energy systems
19PME1-E104	Measurements in Thermal Engineering
19PME1-E105	Energy conservation and Management

Semester – II

Course Code	Course Title
19PME1-E201	Jet and Rocket Propulsion
19PME1-E202	Advanced Cryogenic Systems
19PME1-E203	Design of Wind Power Farms
19PME1-E204	Conjugate Heat Transfer
19PME1-E205	Dynamics and control of Mechanical systems
19PME1-E206	Design and Optimization of Energy systems
19PME1-E207	Boiling and Condensation
19PME1-E208	Simulation of IC engine Processes
19PME1-E209	Nuclear Engineering

The following are planned to be offered as Open Electives by the Mechanical Engineering Department.

OPEN ELECTIVE

Code No.	Subject Name	L-T-P	Cr.
19PME-OE01	Research Methodology	3-0-0	3
19PME-OE02	Industrial Safety and Risk Assessment	3-0-0	3
19PME-OE03	Air Pollution Control Engineering	3-0-0	3
19PME-OE04	Environment & Ecology	3-0-0	3
19PME-OE05	Green Technology	3-0-0	3
19PME-OE06	Micro and Smart Systems	3-0-0	3
19PME-OE07	Entrepreneurship and Startups	3-0-0	3

ADVANCED THERMODYNAMICS

SYLLABUS:

Introduction: Recapitulation of Basic thermodynamics.

Second Law Analysis: Review of entropy, Second law analysis for a control volume, Irreversibility and availability, Exergy balance equation and Exergy analysis.

Thermodynamic relations: For homogeneous phase, Maxwell relations, Relations involving enthalpy, internal energy and entropy Equilibrium between two-phases of a pure substance Clausius- Clapeyron equation.

Review of Ideal Gas & Real Gas: Ideal gas mixtures and mixing rules, Real gas behavior, Real gas equations of state, Property relations for mixtures and Psychrometry.

Introduction to combustion: Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, various combustion mode, Scope of combustion. Thermodynamics of Combustion: Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, Chemical Equilibrium, Chemical potential, Second law analysis of reacting systems, Chemical equilibrium, Free energies, Equilibrium flame temperature, Equilibrium products of combustion.

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Text Books/ References:

1. Moran, M. J., Shapiro, H. N., Boettner, D. D., & Bailey, M. B. (2010). Fundamentals of engineering thermodynamics. John Wiley & Sons.
2. Nag, P. K. (2013). Engineering thermodynamics. Tata McGraw-Hill Education.
3. Çengel, Y. A., & Boles, M. A. (2008). Thermodynamics: An Engineering Approach,. McGraw-Hill.
4. Van Wylen, G. J., & Sonntag, R. E. (1985). Fundamentals of classical thermodynamics (No. 536 VAN).
5. Hawkins, G. A. (1986). Engineering thermodynamics: an introductory textbook. John Wiley & Sons.

ADVANCED HEAT AND MASS TRANSFER

SYLLABUS:

Introduction: Introduction to Heat Transfer – Different Modes, Governing Laws, Applications to Heat Transfer, Simple Problems for a recapitulation of the above.

Steady-state two-dimensional heat conduction problems: Steady-state two-dimensional heat conduction problems in Cartesian and Cylindrical coordinates, Use of Bessel's functions, Numerical Problems.

Extended Surfaces or Fins: Extended Surfaces or Fins of various geometries – Uniform Fins, like Straight Rectangular and Circular Fins, Non-uniform Fins, like Annular Fins and Triangular Fins, Corrected fin-length concept of Harper and Brown, Fin Efficiency and Fin Effectiveness, Numerical Problems covering all the topics.

Transient [Unsteady-state] heat conduction: Transient heat conduction, Different cases - Negligible internal thermal resistance, Negligible surface resistance, Comparable internal thermal and surface resistances, Lumped body, Infinite plate of finite thickness and Semi-infinite Solid, Numerical problems, Heisler and Grober charts for Transient Conduction – Solution to (i) One-dimensional, (ii) Two-dimensional and (iii) Three-dimensional problems using the charts, Numerical problems.

Free convection: Laminar and Turbulent flows, analytical and empirical solutions, Numerical Problems.

Forced Convection: Forced Convection Flow over a flat plate, Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Numerical Problems concerning the above topics, Forced convection flow over cylinders and spheres, Internal forced convection flows – Constant wall temperature and Constant wall heat flux boundaries, laminar and turbulent flow solutions, Numerical Problems.

Thermal Radiation : Prevost's theory, Theories of propagation of thermal radiation, Fundamental principles - White, Opaque, Transparent, Black and Gray bodies, Spectral and Total emissive powers, Wien's, Rayleigh-Jeans and Planck's laws, Spectral energy distribution of a black body, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity – types of emissivity, Numerical Problems, View factor, View factor algebra, Summation rule, Reciprocity Theorem, Hottel's crossed-string method, Electrical resistance concept to tackle two-body enclosures, Numerical problems.

Mass Transfer: Definition, Examples, Fick's law of diffusion, Fick's law as referred to ideal gases, Steady-state Isothermal Equi-molal counter diffusion of ideal gases, Mass diffusivity, Gilliland's equation, Isothermal evaporation of water and its subsequent diffusion into dry air, Mass transfer coefficient, Numerical problems.

Textbooks/ References:

1. Kakaç, S., Yener, Y., & Naveira-Cotta, C. P. (2018). Heat conduction. CRC Press.
2. Kays, W. M. (2012). Convective heat and mass transfer. Tata McGraw-Hill Education.
3. Howell, J. R., Menguc, M. P., & Siegel, R. (2015). Thermal radiation heat transfer. CRC press.
4. Cengel, Y. (2014). Heat and mass transfer: fundamentals and applications. McGraw-Hill Higher

Education.
5. Sachdeva, R. C. (2009). Fundamentals of engineering heat and mass transfer. New Age Science.
6. Holman, J. P. (2002). Heat Transfer-Si Units-Sie. Tata McGraw-Hill Education.

ADVANCED PRIME MOVERS FOR AUTOMOBILES

SYLLABUS:

Introduction to IC engines: Overview of the course, Examination and Evaluation patterns-Classification **of** Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-s cycle engines based on scavenging, Differences between 2-s and 4-s cycle engines, Differences between SI and CI engines.

Two-stroke engines: Definition of parameters-Scavenging Efficiency, Delivery ratio and trapping Efficiency, Theoretical Scavenging Processes-Practical Scavenging Systems- Kadenacy effect-Numerical problems on 2-stroke cycle engines.

Spark Ignition Engines: Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines.

Compression Ignition Engines: Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI).Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI),Fuel Injectors-Nozzle types, Electronic Control Unit (ECU) -Numerical problems on fuel injection.

Supercharging of IC Engines: Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

Pollutant emissions from IC Engines: Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NO_X) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

Performance of IC Engines: Classification of engine performance parameters-Measurement of brake power, indicated power and friction power. Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

Alternate Fuels: Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

Electric vehicles: Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability.

Hybrid vehicle: Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability-Hydrogen: Production-Hydrogen storage systems-reformers.

Batteries: Battery: lead-acid battery, cell discharge and charge operation, construction, advantages of lead-acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

Fuel Cell vehicles: Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

Text Books/ References:

1. Heywood, J. B. (1988). Internal combustion engine fundamentals.

2. Pulkrabek, W. W. (2014). Engineering fundamentals of the internal combustion engine. Upper Saddle River: Pearson Prentice Hall.

3. Leitman, S., & Brant, B. (2013). Build your own electric vehicle. McGraw-Hill Education.

4. Barbir, F. (2012). PEM fuel cells: theory and practice. Academic Press.

NUMERICAL METHODS IN THERMAL ENGINEERING

SYLLABUS:

Solution of Linear Algebraic Equations: Gaussian elimination, LU decomposition, Pivoting strategies, Operation Count, Matrix inversion, Special cases, Tridiagonal and block tridiagonal systems, Well-conditioned and ill conditioned system, Matrix and Vector norms, Condition Number and its implications.

Solution of Non-linear Algebraic Equations: Bisection, Newton-Raphson and Secant method, System of non-linear equations, Basics of finite difference method.

Discretization of spatial and time derivatives using Taylor's series, Truncation error and the order of discretization, Fourier (von Neumann) stability analysis.

Solution of Ordinary Differential Equations, Initial Value problems, Euler explicit and implicit methods, Runge-Kutta method, Predictor-Corrector methods, Boundary value problem, Shooting method, Finite difference method applied to pin fin heat dissipation, Stiff problems, Meaning of stiffness, Further insights into stiffness by the application of Euler explicit and implicit method to a stiff problem, Solution of stiff problem, Example – Chemical kinetics.

Solution of Elliptic Partial Differential Equations, Physical problems governed by elliptic PDE's, Five-point and nine-point discretization of Poisson's equation, Iterative methods, Point Iterative methods – Jacobi, Gauss-Seidel, and SOR, Detailed theory of the convergence of iterative methods, Global Iterative methods – Steepest Descent and Conjugate Gradient.

Classification of PDEs and characteristics of a PDE, Solution of Parabolic Partial Differential Equations, Physical problems governed by parabolic PDE's Operator splitting and ADI methods.

Assignments on the topics should be given to solve using computer code.

Text Books/ References:

1. Cheney, E. W., & Kincaid, D. R. (2012). Numerical mathematics and computing. Cengage Learning.
2. Gerald, C. F., & Wheatley, P. O. (2013). Applied Numerical Analysis. Seventh.
3. Isaacson, E., & Keller, H. B. (2012). Analysis of numerical methods. Courier Corporation.
4. Smith, G. D. (1985). Numerical solution of partial differential equations: finite difference methods. Oxford university press.
5. Golub, G. H., & Van Loan, C. F. (2012). Matrix computations (Vol. 3). JHU press.
6. Press, W. H., Flannery, B. P., Teukolsky, S. A., & Vetterling, W. T. (1989). Numerical recipes.

THERMAL ENGINEERING LABORATORY

SYLLABUS:

Pin-Fin Apparatus: Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment.

Natural Convection Apparatus: Determination of experimental and empirical values of convection heat transfer coefficient from a Vertical Heated Cylinder losing heat to quiescent air.

Forced Convection Apparatus: Determination of theoretical, experimental and empirical values of convection heat transfer coefficient for internal forced convection through a circular GI pipe.

Abel's apparatus: Determination of flash and fire points of a given oil sample.

Redwood Viscometer No. 1: Determination of kinematic and absolute viscosities of an oil sample given

Distillation apparatus: Determination of distillation characteristic of a given sample of gasoline.

Two-Stage Reciprocating Air-Compressor: Determination of volumetric efficiency of the compressor as a function of receiver pressure.

IC Engines: Valve and Port Timing Diagrams on 4-stroke and 2-stroke IC Engines. Valve Timing Diagrams on 4-stroke CI Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Constant Speed Performance Test on Single-Cylinder Kirloskar CI Diesel Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Motoring Test on Single-Cylinder Kirloskar CI Diesel Engine.

Single-Cylinder Kirloskar CI Diesel Engine: Retardation Test on Single-Cylinder Kirloskar CI Diesel Engine.

Text Books/ References:

1. Ozisik, M. N. (1985). Heat transfer: a basic approach.
2. Incropera, F. P., Lavine, A. S., Bergman, T. L., & DeWitt, D. P. (2007). Fundamentals of heat and mass transfer. Wiley.
3. Holman, J. P. (2002). Heat Transfer-Si Units-Sie. Tata McGraw-Hill Education.
4. Ganesan, V., Fundamentals of IC Engines, Tata McGraw Hill, 2003.

GAS TURBINES AND JET PROPULSION

SYLLABUS:

Introduction: Classification of Turbomachines, Applications of Gas Turbines, Assumptions for Air-Standard Cycles, Simple Brayton Cycle, Heat Exchange Cycle, Inter-cooling and Reheating Cycle, Comparison of Various Cycles.

Ideal Shaft Power Cycles and their Analysis: Assumptions for Air-Standard Cycles, Simple Brayton Cycle, Heat Exchange Cycle, Inter-cooling and Reheating Cycle, Comparison of Various Cycles.
Real Cycles and their Analysis: Methods of Accounting for Component Losses, Isentropic and Polytropic Efficiencies, Transmission and Combustion Efficiencies, Comparative Performance of Practical Cycles, Combined Cycles and Cogeneration Schemes.

Jet Propulsion Cycles and their Analysis: Criteria of Performance, Simple Turbojet Engine, Simple Turbofan Engine, Simple Turboprop Engine, Turbo-shaft Engine, Thrust Augmentation Techniques
Fundamentals of Rotating Machines: General Fluid Dynamic Analysis, Euler's Energy Equation, Components of Energy Transfer, Impulse and Reaction Machines.
Centrifugal Compressors: Construction and Principle of Operation, Elementary Theory and Velocity Triangles, Factors Effecting Stage Pressure Ratio, The Diffuser, The Compressibility Effects, Pre-rotation and Slip Factor, Surging and Choking, Performance Characteristics.

Flow Through Cascades: Cascade of Blades, Axial Compressor Cascades, Lift and Drag Forces, Cascade Efficiency, Cascade Tunnel.

Axial Flow Compressors: Construction and Principle of Operation, Elementary Theory and Velocity Triangles, Factors Effecting Stage Pressure Ratio, Degree of Reaction, Work done factor, Three Dimensional Flow, Design Process, Blade Design, Stage Performance, Compressibility Effects, Off-Design Performance.

Combustion System: Operational Requirements, Classification of Combustion Chambers, Factors Effecting Combustion Chamber Design, The Combustion Process, Flame Stabilization, Combustion Chamber Performance, Some Practical Problems Gas Turbine Emissions.

Axial and Radial Flow Turbines: Construction and Operation, Vortex Theory, Estimation of Stage Performance, Overall Turbine Performance, Turbine Blade Cooling, the Radial Flow Turbine. Off-Design Performance: Off-Design Performance of Single Shaft Gas Turbine, Off-Design Performance of Free Turbine Engine, Off-Design Performance of the Jet Engine, Methods of Displacing the Equilibrium Running Line.

Text Books/ References:

1. Saravanamuttoo, H. I., Rogers, G. F. C., & Cohen, H. (2001). Gas turbine theory. Pearson Education.
2. Hall, C., & Dixon, S. L. (2013). Fluid mechanics and thermodynamics of turbomachinery. Butterworth-Heinemann.
3. Flack, R. D. (2005). Fundamentals of jet propulsion with applications (Vol. 17). Cambridge University Press.
4. Ganesan, V. (2010). Gas Turbines 3E. Tata McGraw-Hill Education.
5. Yahya, S. M. (1987). Turbines compressors and fans. Tata McGraw-Hill Education.
6. Lefebvre, A. H., & Ballal, D. R. (2010). Gas turbine combustion: alternative fuels and emissions. CRC press.

COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

SYLLABUS:

Introduction: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods.

Governing equations of fluid dynamics: Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.

Mathematical behavior of partial differential equations: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

Basic aspects of discretization: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

Grids with appropriate transformation: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

Parabolic partial differential equations: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

Stability analysis: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, artificial dissipation and dispersion.

Elliptic equations: Finite difference formulation, solution algorithms: Jacobi-iteration method, a Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, and alternative direction implicit methods.

Hyperbolic equations: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.

Scalar representation of navier-stokes equations: Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, BTCS and BTBCs implicit algorithms, applications.

Grid generation: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation.

Finite volume method for unstructured grids: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetra hedral Elements, 2-D Heat conduction with Triangular Elements.

Numerical solution of quasi one-dimensional nozzle flow: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.

Text Books/ References:

1. Anderson, J. D., & Wendt, J. (1995). Computational fluid dynamics (Vol. 206). New York: McGraw-Hill.
2. Hoffmann, K. A., & Chiang, S. T. (2000). Computational fluid dynamics volume I. Engineering Education System.
3. Chung, T. J. (2010). Computational fluid dynamics. Cambridge university press.
4. Anderson, D., Tannehill, J. C., & Pletcher, R. H. (2016). Computational fluid mechanics and heat transfer. CRC Press.
5. Versteeg, H. K., & Malalasekera, W. (2007). An introduction to computational fluid dynamics: the finite volume method. Pearson education.

SEMINAR

Identify and compare technical and practical issues related to the area of course specialization. Outline annotated bibliography of research demonstrating scholarly skills. Prepare a well-organized report employing elements of technical writing and critical thinking Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

CFD LABORATORY-I

SYLLABUS:

1. Solution of 1D heat conduction problem using TDMA and LU decomposition.
2. Solution of 2D parabolic equations.
    (a) Explicit
    (b) Implicit (ADI)
3. Grid generation (rectangular and circular).
4. Introduction to ANSYS FLUENT
    ANSYS FLUENT 1 (Laminar pipe Flow).
    ANSYS FLUENT 2 (Turbulent Pipe Flow).
    ANSYS FLUENT 3 (2D circular Cylinder).
    ANSYS FLUENT 4 (2D airfoil).
    ANSYS FLUENT 5 (Driven Cavity).

Text Books/ References:

1. Versteeg, H. K. and Malalasekera, W. (2010). An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H. (2002) Computational Fluid Mechanics and Heat Transfer, McGraw Hill.
3. Blazek, J., (2006) Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology.
4. Chung, T. J. (2003) Computational Fluid Dynamics, Cambridge University Press.

(Electives- Semester-I)

INCOMPRESSIBLE AND COMPRESSIBLE FLOWS

SYLLABUS:

Introduction: Introduction to Fluid Mechanics-Properties of Fluids, Fluid Statics: Fluid Statics, Fundamental Equations-Applications of Fundamental Equations, Relative Motion of Liquids.

Kinematics of Fluids: Kinematics of Fluids- Review of basics-Velocity potential, Stream function and Vorticity.

Theory of Stress and Rate of Strain: General theory of Stress and Rate of Strain Fundamental Equations – Integral form-Fundamental Equations – Integral form-Reynolds Transport Theorem-Applications of the Integral Form of Equations-Numerical.

Fundamental Equations in Differential Form: Fundamental: Equations in Differential Form-One-dimensional Inviscid Incompressible Flow-Euler's Equation and Bernoulli's Equation-Applications of the Bernoulli's Equations-Numerical.

Two and Three – dimensional Inviscid Incompressible Flow: Two and Three – dimensional Inviscid Incompressible Flow-Laminar Flow- Flow between Parallel Flat plates-Steady Flows in Pipes-Applications of Laminar Flow-Numericals.

The Laminar Boundary layer: The Laminar Boundary layer – Prandtl's Boundary Layer Equations-The Boundary layer along a Flat Plate-Solution to the Boundary Layer Equations-Momentum Integral Equation-Separation of Boundary Layer and Control-Numericals.

Turbulent Flow: Introduction to Turbulent Flow – Modified N-S Equations-Semi - empirical Theories-Turbulent Boundary Layer-Numericals.

Dimensional Analysis: Flow over a bluff body – Lift and Drag-Dimensional Analysis and Similitude.

Introduction to Compressible Flow: Introduction to Compressible Flow – review of Fundamentals-Stagnation Properties – Relations and Tables-Numericals.

Wave Motion: Wave Motion-Propagation of Motion in Compressible Fluids-Mach number and Mach Cone-Numericals.

Isentropic Flow: Isentropic Flow Relations-Flow through Nozzles and Diffusers-Isentropic Flow Relations and Tables-Numericals.

Flow across Normal Shock and Oblique Shock: Basic Equations Normal Shock – Prandtl-Meyer Equation, Oblique shock-Property variation – Relations and Tables-Numericals.

Flow through a constant area duct with Friction: Flow through a constant area duct with Friction-Fanno Line, Fanno Flow -Variation of Properties – Relations and Tables-Numericals. Flow through a constant area duct with Heat Transfer-Flow through a constant area duct with Heat Transfer-Rayleigh Line, Rayleigh Flow – Variation of Properties – Relations and Tables-Numericals.

Text Books/ References:

1. Yuan, S. W. (1970). Foundations of fluid mechanics. Prentice-Hall.
2. Yahya, S. M. (2010). Fundamentals of Compressible Flow: With Aircraft and Rocket Propulsion. New Age Science.
3. Schlichting, H., & Gersten, K. (2016). Boundary-layer theory. Springer.
4. White, F. M., & Corfield, I. (2006). Viscous fluid flow (Vol. 3, pp. 433-434). New York: McGraw-Hill.

HEATING, VENTILATING, AND AIR-CONDITIONING

SYLLABUS:

Introduction - Purpose, applications, definition and components of air conditioning - Need and methods of ventilation - Course outline.

Psychrometry - Evolution of air properties and psychrometric chart - Basic processes such as sensible heating/cooling, humidification/dehumidification and their combinations, steam and adiabatic humidification, adiabatic mixing, etc. - Bypass factor and Sensible heat ratio.

Summer and Winter AC - Simple summer AC process, Room sensible heat factor, Coil sensible heat factor, ADP - Precision AC - Winter AC.

Human Comfort - Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort - Thermal response - comfort factors - Environmental indices - Indoor air quality.

AC Equipments - Filters, types, efficiency - Fans basic equations, parallel and series configurations - Air washer, adiabatic, heated and cooled - Cooling tower, enthalpy potential, types, tower efficiency, NTU and characteristics, sizing and off design performance - Cooling and dehumidifying coil, dry and wet, sizing, performance.

Heat Transfer - Heat transfer in wall and roof, sol-air temperature, insulation, cooling load temperature difference - Fenestration, types of glass, sun shade, shading coefficient, maximum radiation, cooling load factor.

Cooling Load Estimation - Design conditions, outdoor, indoor - External load, wall, roof, glass - Internal load, occupancy, lighting, equipment’s - Ventilation, air quantity, loads - Load estimation methods.

Heating load estimation - Vapour transfer in wall, vapour barrier, load estimation basics.

Air Distribution - Ducts, types, fittings, air flow, friction chart, methods of sizing, balancing.

Air Diffusion - Isothermal jet, throw, drop, types of outlets, ADPI, outlet/inlet selection.

Basics of Ventilation - Need, threshold limits of contaminants, estimation of ventilation rates, decay equation, air flow round buildings.

Methods of Ventilation - Natural, wind effect, stack effect, combined effect - Mechanical, forced, exhaust, combined - Displacement ventilation

Industrial Ventilation - Steel plants, car parks, plant rooms, mines, etc.

Ventilation System Design - Exhaust ducts, filters, blowers, hoods, chimney, etc.

Text Books/ References:

1. Handbook-Fundamentals, A. S. H. R. A. E. (2009). American society of Heating. Refrigerating and Air-Conditioning Engineers.
2. Kuehn, T. H., Ramsey, J. W., & Threlkeld, J. L. (1998) Thermal environmental engineering.
3. Clements-Croome, D., & Roberts, B. M. (1975). Airconditioning and ventilation of buildings (Vol. 10). Pergamon.
4. Stoecker, W. F., & Jones, J. W. (1982). Refrigeration and air conditioning,. Mc GrawHill Book Co, New York.
5. Arora, C. P. (2003). Refrigeration and Air Conditioning. 9th reprint. Tata-McGraw-Hill, New Delhi,

ALTERNATE FUELS AND ENERGY SYSTEMS

SYLLABUS:

Introduction: Estimation of petroleum reserve – Need for alternate fuels – Availability and properties of alternate fuels, ASTM standards

Alcohols: General Use of Alcohols – Properties as Engine fuel – Gasolene and alcohol blends – Performance in SI Engine – Methanol and Gasolene blend – Combustion Characterstics in engine – emission characteristics

Vegetable oils: Soyabeen Oil, Jatropha, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils

Natural Gas, LPG: Availability of CNG, properties, modification required to use in engines – performance and emission characterstics of CNG using LPG in SI & CI engines.

Hydrogen: Hydrogen production, Hydrogen as an alternative fuel, fuel cell

Electric and Solar powered vehicles: Layout of an electric vehicle – advantage and limitations- specificatios –system component – electronic control system – High energy and power density batteries – Hybrid vehicle – solar powered vehicles

Automobile emissions & its control: Need for emission control -Classification/ categories of emissions - Major pollutants - control of emissions – Evaluating vehicle emissions – EURO I,II,III,IV standards – Indian standards

Text Books/ References:

1. Richard, L. (1997). Alternative Fuels Guidebook Properties, Storage, Dispensing and Vehicle Facility Modifications. Society of Automotive Engineers (SAE), 1-721.

2. Norbeck, J. M., Heffel, J. W., Durbin, T. D., Tabbara, B., Bowden, J. M., & Montano, M. C. (1996). Hydrogen fuel for surface transportation (Vol. 160).

3. Wakefield, E. H. (1998). History of the Electric Automobile-Hybrid Electric Vehicles (Vol. 187)

4. Pundir, B. P. (2007). Engine emissions: pollutant formation and advances in control technology. Alpha Science International, Limited.

5. S.C. Bhatia (2007) Air Pollution and its Control, Atlantic Publications,

6. Halderman, J. D., & Linder, J. (2011). Automotive fuel and emissions control systems. Pearson Higher Ed.

MEASUREMENTS IN THERMAL ENGINEERING

SYLLABUS:

Basics of Measurements: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction.

Analysis of experimental data: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.

Sensing Devices: Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

Pressure measurement: Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

Thermometry: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer.

Flow Measurement: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods.

Thermal and transport property measurement: Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

Nuclear, thermal radiation measurement: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.

Air-Pollution: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement.

Advanced topics: Issues in measuring thermos physical properties of micro and Nano fluids.

Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS.

Text Books/ References:

1. Beckwith, T. G., Marangoni, R. D., & Lienhard, J. H. (2009). Mechanical measurements. Pearson.
2. Doebelin, E. O., & Manik, D. N. (2007). Measurement systems: application and design.
3. Holman, J. P., & Gajda, W. J. (2001). Experimental methods for engineers (Vol. 2). New York: McGraw-Hill.

ENERGY CONSERVATION AND MANAGEMENT

SYLLABUS:

Energy Scenario: Classification of Energy, Indian energy scenario, Sectorial energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, energy security, energy conservation and its importance, energy strategy for the future. Energy Conservation Act 2001 and related policies: Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies, Electricity Act 2003, Integrated energy policy, National action plan on climate change, ECBC code for Building Construction.

Financial Management and Energy Monitoring and Targeting: Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of Energy Service Companies (ESCOs).

Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques – energy consumption, production, cumulative sum of differences (CUSUM). Energy Management Information Systems (EMIS).

Energy Efficiency in Thermal Utilities and systems: Boilers: Types, combustion in boilers, performances evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities. Boiler efficiency calculation, evaporation ratio and efficiency for coal, oil and gas. Soot blowing and soot deposit reduction, reasons for boiler tube failures, start up, shut down and preservation, Thermic fluid heaters, super critical boilers.

Steam System: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings. Steam utilization, Performance assessment more details, installation, thermo-compressor, steam pipe insulation, condensate pumping, steam dryers.

Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery. Forging furnace heat balance, Cupola, non-ferrous melting, Induction furnace, performance evaluation of a furnace, hot air generators.

Insulation and Refractories: Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. Cold insulation.

Heat Exchangers: Types, networking, pinch analysis, multiple effect evaporators, condensers, distillation column, etc.

Waste Heat Recovery: Classification, advantages and applications, commercially viable waste heat recovery devices, saving potential.

Cogeneration: Definition, need, application, advantages, classification, saving potentials. Heat balance, steam turbine efficiency, tri-generation, micro turbine.

Text Books/ References:

1. Fardo, S. W., Patrick, D. R., Richardson, R. E., & Fardo, B. W. (2015). Energy conservation guidebook. Lulu Press, Inc.
2. Thumann, A., & Younger, W. J. (2008). Handbook of energy audits. The Fairmont Press, Inc.
3. Bureau of Energy Efficiency Reference book: No.1, 2, 3 4.
4. Doty, S., & Turner, W. C. (2004). Energy management handbook. Crc Press.
5. Wilson, E., & Gerard, D. (2007). Carbon capture and sequestration: integrating technology, monitoring, regulation.
6. Kreider, J. F., Curtiss, P. S., & Rabl, A. (2009). Heating and cooling of buildings: design for efficiency. CRC Press.

(Electives- Semester-II)

JET AND ROCKET PROPULSION

SYLLABUS:

Motion in Space: Requirement for Orbit: Motion of Bodies in space, Parameters describing motion of bodies, Newton's Laws of motion, Universal law of gravitational force, Gravitational field, Requirements of motion in space, Geosynchronous and geostationary orbits, Eccentricity and inclination of orbits, Energy and velocity requirements to reach a particular orbit, Escape velocity, Freely falling bodies, Means of providing the required velocities.

Theory of Rocket Propulsion: Illustration by example of motion of sled initially at rest, Motion of giant squid in deep seas, Rocket principle and rocket equation, Mass ratio of rocket, Desirable parameters of rocket, Rocket having small propellant mass fraction, Propulsive efficiency of rocket, Performance parameters of rocket, Staging and clustering of rockets, Classification of rockets.

Rocket nozzle and Performance: Expansion of gas from a high pressure chamber, Shape of the nozzle, Nozzle area ratio, Performance loss in conical nozzle, Flow separation in nozzles, Contour or bell nozzles, Unconventional nozzles, Mass flow rates and characteristics velocity, Thrust developed by a rocket; Thrust coefficient, Efficiencies, Specific impulse and correlation with C* and CF, General Trends.

Chemical Propellants: Small value of molecular mass and specific heat ratio, energy release during combustion of products, Criterion for choices of propellants, Solid propellants, Liquid propellants, Hybrid propellants.

Solid Propellants Rockets: Mechanism of burning and burn rate, Choice of index n for stable operation of solid propellant rockets, Propellant grain configuration, Ignition of solid propellant rockets, Pressure decay in chamber after propellant burnout, Action time and burn time, Factors influencing burn rate, Components of a solid propellant rocket.

Liquid Propellant Rockets: Propellant feed system, Thrust chamber, Performance and choice of feed system cycle, Turbo pumps, Gas requirements for draining of propellants from storage tanks, Draining under microgravity condition, Trends in development of liquid propellant rockets.

Hybrid Rockets: Working principle, Choice of fuels and oxidizer, Future of hybrid rockets.

Text Books/ References:

1. Barrere, M., Jaumotte, A., Fraeijs de Veubeke, B., & Vandenkerckhove, J. (1960). Rocket propulsion (No. OA-2). LTAS
2. Sutton, G. P., & Biblarz, O. (2001). Rocket Propulsion Elements JOHN WILEY & SONS. Inc., New York.
3. Ramamurthi, K. (2010). Rocket Propulsion. Macmillan.
4. Feodosiev, V. I., & Siniarev, G. B. (2014). Introduction to rocket technology. Academic Press.
5. Saravanamutto, H., Rogers, G., Cohen, H., & Straznicky, P. (2008). Gas Turbine Theory, 6th red.

ADVANCED CRYOGENIC SYSTEMS

SYLLABUS:

Introduction: Definition and Engineering Applications of Cryogenics, Properties of solids for cryogenic systems.

Refrigeration and Liquefaction: Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle.

Ultra-low-temperature refrigerators: Definition and Fundamentals regarding ultra-low-temperature refrigerators, Equipment associated with low-temperature systems, Various Advantages and Disadvantages.

Storage and Handling of Cryogenic Refrigerants: Storage and Transfer systems, Insulation, Various Types of Insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.

Applications: Broad Applications of Cryogenic Refrigerants in various engineering systems

Text Books/ References:

1. Frederking, T. H., & Yuan, S. W. (2005). Cryogenics: low temperature engineering and applied sciences. Yutopian Enterprises.
2. Arora, C. P. (2000). Refrigeration and air conditioning, New Delhi.
3. Jha, A. R. (2011). Cryogenic technology and applications. Elsevier.

DESIGN OF WIND POWER FARMS

SYLLABUS:

General Introduction to Wind Turbines, classification & status. Thermodynamic analysis and Betz theory. Fluid dynamic analysis of wind source and classification of sources.

2-D aerodynamics of wind turbine & blade.

3-D aerodynamics of blade.

Aerodynamics of rotor wakes and selection of number of blades & speed.

Analysis of rotor design and selection of capacity.

Design of horizontal axis wind turbines.

Design of vertical axis wind turbines.

Controls for wind turbines.

Auxiliary systems.

Special designs for micro wind turbines.

Text Books/ References:

1. Hansen, M. O. L. (2008). Aerodynamics of Wind Turbine second edition Earthscan. London, UK.
2. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi (2010) Wind Energy Handbook, John Wiley and Sons.
3. Abbott, I. H., & Von Doenhoff, A. E. (1959). Theory of Wing Sections Dover Publications Inc.

CONJUGATE HEAT TRANSFER

SYLLABUS:

Introduction: Definition of conjugate heat transfer, basics, applications in engineering practice and research.

Review of Fundamentals: Review of fundamentals of energy balance approach, view factor calculations, Algebra of view factors, Enclosure Analysis, Radiosity - irradiation methods.

Finite volume and finite difference methods: Principles and Applications of finite volume and finite difference methods, Practice of computer programs for simple problems

Two-mode heat transfer problems: Conjugate convection from different geometries without radiation, Applications in Electronics Cooling and other related appliances.

Three-mode heat transfer problems: Conjugate convection with radiation from various geometries, Applications in Electronics Cooling and other related appliances.

Conjugate mixed convection problems: Problems of the above kind as referred to Gas cooled nuclear reactors, Electronics cooling appliances, and so on.

Text Books/ References:

1. Kakaç, S., Yener, Y., & Naveira-Cotta, C. P. (2018). Heat conduction. CRC Press.
2. Kays, W. M. (2012). Convective heat and mass transfer. Tata McGraw-Hill Education.
3. Howell, J. R., Menguc, M. P., & Siegel, R. (2015). Thermal radiation heat transfer. CRC press.
4. Bergman, T. L., Incropera, F. P., DeWitt, D. P., & Lavine, A. S. (2011). Fundamentals of heat and mass transfer. John Wiley & Sons.

DYNAMICS AND CONTROL OF MECHANICAL SYSTEMS

SYLLABUS:

Basic Concepts: Inertial Coordinate System. Fundamental Laws of Motion. Mechanics of Particles and System of Particles. Principle of Linear and Angular Momenta. Work-energy principles.

Lagrangian Dynamics: Degrees of Freedom. Generalized Coordinates and Generalized Forces. Holonomic and Nonholonomic Constraints, Lagrange's Equation from D'Alembert's Principles. Application of Lagrange's equation for Conservative and Non-conservative Autonomous Systems with holonomic and Nonholonomic Constraints. Applications to systems with very Small Displacements and Impulsive Motion. Hamilton Principle from D'Alembert's Principle. Lagrange Equation from Hamilton's Principle.

Multi-body Dynamics: Space and Fixed body Coordinate Systems. Coordinate Transformation Matrix. Direction Cosines, Euler Angles. Euler Parameters. Finite and Infinitesimal Rotations. Time Derivatives of Transformations Matrices. Angular Velocity and Acceleration Vectors. Equations of Motion of Multi-Body System. Newton-Euler Equations. Planer Kinematic and Dynamic Analysis. Kinematic Revolute Joints. Coordinate Partitioning, Equations of Motion. Joint Reaction Forces. Simple Applications of Planer Systems.

Stability of Motion: Fundamental Concept in Stability. Autonomous Systems and Phase Plane Plots. Routh's Criteria for Stability. Liapunv's Method. Liapunov's Stability Theorems. Liapunov's Function to Determine Stability of the System.

Control System Dynamics: Open and Close Loop Systems. Block Diagrams. Transfer Functions and Characteristics Equations. Proportional Integral and Derivative Control actions and their Characteristics.

Text Books/ References:

1. Ginsberg, J. H. (1998). Advanced engineering dynamics. Cambridge University Press.
2. Meirovitch, L. (2010). Methods of analytical dynamics. Courier Corporation.
3. Canon, R. (1967). Dynamics of Physical Systems, ch. 4.

DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS

SYLLABUS:

Introduction: Introduction to design and specifically system design. Morphology of design with a flow chart. Very brief discussion on market analysis, profit, time value of money, an example of discounted cash flow technique. Concept of workable design, practical example on workable system and optimal design.

System Simulation: Classification. Successive substitution method - examples. Newton Raphson method - one unknown - examples. Newton Raphson method - multiple unknowns - examples. Gauss Seidel method - examples. Rudiments of finite difference method for partial differential equations, with an example.

Regression and Curve Fitting: Need for regression in simulation and optimization. Concept of best fit and exact fit. Exact fit - Lagrange interpolation, Newton's divided difference - examples. Least square regression - theory, examples from linear regression with one and more unknowns - examples. Power law forms - examples. Gauss Newton method for non-linear least squares regression - examples.

Optimization: Introduction, Formulation of optimization problems – examples. Calculus techniques – Lagrange multiplier method – proof, examples. Search methods – Concept of interval of uncertainty, reduction ratio, reduction ratios of simple search techniques like exhaustive search, dichotomous search, Fibonacci search and Golden section search – numerical examples. Method of steepest ascent/ steepest descent conjugate gradient method – examples. Geometric programming – examples. Dynamic programming – examples. Linear programming – two variable problem –graphical solution. New generation optimization techniques – Genetic algorithm and simulated annealing -examples.

Text Books/ References

1. Balaji, C. (2011). Essentials of thermal system design and optimization. Ane Books Pvt.
2. Jaluria, Y. (2007). Design and optimization of thermal systems. CRC press.
3. Burmeister, L. C. (1998). Elements of thermal-fluid system design (p. 220). New Jersey: Prentice Hall.
4. Stoecker, W. F. (1980). Design of thermal systems. McGraw Hill Book Company.
5. Arora, J. S. (2004). Introduction to optimum design. Elsevier.
6. Deb, K. (2012). Optimization for engineering design: Algorithms and examples. PHI Learning Pvt. Ltd.

BOILING AND CONDENSATION

SYLLABUS:

Introduction: boiling and condensation, Basics. Pool Boiling -Nucleation, vapor bubble dynamics, heat transfer, critical heat flux. Flow Boiling -Pressure drop, sub cooled boiling, saturated boiling, boiling crisis (CHF), post-dry out heat transfer.

Two-Phase Micro channel Heat Sinks. Film Condensation of Stagnant vapors - Nusselt theory, effect of resistance by the film and interface. Drop Condensation of Stagnant vapors. Condensation of Flowing vapors. Enhancement of Heat transfer during Boiling and Condensation

Text Books/ References:

1. Stephan, K. (1992). Heat transfer in condensation and boiling (p. 84). Berlin: Springer-Verlag.
2. Collier, J. G., & Thome, J. R. (1994). Convective boiling and condensation. Clarendon Press.
3. Perez-Blanco, H. (1997). Boiling Heat Transfer and Two-Phase Flow.

SIMULATION OF IC ENGINE PROCESSES

SYLLABUS:

Basics of different types of IC engines; gas exchange processes; combustion and heat transfer processes; engine cycle events a ideal and actual cycles; estimation of the composition and properties of unburned and burned mixtures; spray processes; modeling of homogeneous and heterogeneous charge engines; estimation of engine heat transfer; engine friction calculations; scavenging models; applications to engine development.

Text Books/ References:

1. Heywood, J. B. (1988). Internal combustion engine fundamentals. McGraw Hill.
2. Research Papers.

NUCLEAR ENGINEERING

SYLLABUS

Basics of nuclear physics: Nuclear dimension, constituent particles, mass, magnetic moment, electric moment, nuclear shape, nuclear binding energy and stability. Structure of the nucleus: liquid drop and nuclear shell model.

Interaction of nuclear radiation with matter and nuclear detection technology: Interaction of charged particles (like alpha, beta, heavy ions etc.) and photons with material media, their energy loss characteristics. Different nuclear detectors like gas ionization chamber, proportional counter, G-M counter, solid-state surface barrier detectors, scintillation counter with photomultiplier tube. Basic concepts of nuclear electronics associated with these detectors for data acquisition, Application of nuclear detectors in science and technology.

Nuclear reactions: Q-value and a classical approach of compound nucleus formation as a possible mechanism of nuclear reaction, Different examples of nuclear reactions, Energy release in nuclear fission and fusion reactions.

Fission and fusion reactors: Fission reactor- Nuclear chain reaction, critical size, reproduction factor, design of a power reactor with fuel core, moderator, reflector, coolant, control, safety and nuclear breeding process. Fusion reactor- Lawson criteria, heating of plasma, confinement of plasma in magnetic mirror and tokamak, basic concepts of plasma instabilities, generation of nuclear power and future challenges.

Radioactivity and its applications: Laws of radioactivity, decay constant, half-life, mean life, activity, Geiger-Nuttal law, theory of successive transformation, radioactive equilibrium, radioactive dating methods and accelerator mass spectrometry in geology and archeology.

Nuclear Medicine: Production of various radioactive isotopes, application of the isotope in therapeutic process like gamma ray therapy, boron neutron capture therapy, heavy ion therapy applications of radioisotopes in imaging process like, gamma camera, positron emission tomography and magnetic resonance imaging are discussed.

Text Books/ References:

1. Cohen, B. L. (1971). Concepts of nuclear physics. Tata McGraw-Hill Education.
2. Heyde, K. (2004). Basic ideas and concepts in nuclear physics: an introductory approach. CRC Press.
3. WR Leo. (1993). Techniques for Nuclear and Particle Physics Experiments;
4. Knoll, G. F. (2000). Radiation Detection and Measurement, John Wiley & Sons. Inc., New York, 2000.
5. Glasstone, S., & Sesonske, A. (2012). Nuclear reactor engineering: reactor systems engineering. Springer Science & Business Media.
6. Littlefield, T. A. (2012). Atomic and nuclear physics: an introduction. Springer Science & Business Media.

RESEARCH METHODOLOGY

SYLLABUS:

Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process.

Problem Identification & Formulation: Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance.

Research Design: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.

Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches.

Measurement: Concept of measurement– what is measured? Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio.

Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample- Practical considerations in sampling and sample size.

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

Interpretation of Data and Paper Writing – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline.

Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.

Text Books/ References:

1. Blumberg, B., Cooper, D. R., & Schindler, P. S. (2008). Business research methods (Vol. 2). London: McGraw-Hill Higher Education
2. Bell, E., Bryman, A., & Harley, B. (2018). Business research methods. Oxford university press.
3. Kothari, C. R. (2017). Research Methodology methods and techniques second edition.

INDUSTRIAL SAFETY AND RISK ASSESSMENT

SYLLABUS:

Introduction to Industrial Safety: History and development of safety movement, Need for safety, Safety legislation: Acts and rules, Safety standards and codes, Safety policy: safety organization and responsibilities and authorities of different levels. Accident sequence theory Causes of accidents, Accident prevention and control techniques, Plant safety inspections, Job safety Analysis and investigation of accidents, First aid. Financial costs-direct and indirect social costs of accidents. Compilation procedure for financial costs. Cost data, quality and its limitations-Budgeting.

Risk Assessment: Checklist procedure, Preliminary hazard analysis, What if analysis, Failure mode effect analysis, Hazard and operability (HAZOP) studies, Hazard analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index, Risk estimation and management, Major hazard control, On-site and Off-site emergency preparedness.

Hazard Identification of hazard: Categorization methods for elimination of hazard, Mechanical hazards; machine guarding, safety with hand tools/ portable power tools, Pressure vessel hazards and their control, Safety in material handling: hazards and safe Practices, safety with storage of materials, Electrical hazards: classification, safe work practices, Chemical hazards: laboratory safety, bulk handling of chemicals, Fire and explosion hazards, Fire detection, Prevention, control, and extinguishments, Industrial layout, Industrial waste management.

Text Books and References:

1. Jain, R. K., & Rao, S. S. (2008). Industrial safety, health and environment management systems. Romesh Chander Khanna.
2. Slote, L. (1987). Handbook of occupational safety and health.
3. Lees, F. (2012). Lees' Loss prevention in the process industries: Hazard identification, assessment and control. Butterworth-Heinemann.
4. Publications from Inter National standard organizations like ISO, OSHA, IOSH, NEBOSH etc.

AIR POLLUTION CONTROL ENGINEERING

SYLLABUS:

Introduction to air pollution: Concepts, Scales of air pollution, Primary and secondary pollutants, The Earth's atmosphere: structure, composition and energy balance

Main atmospheric pollutants and transformations: Carbon monoxide, Sulfur dioxide, Oxides of nitrogen, Hydrocarbons, Atmospheric aerosol

Transport and dispersion of air pollutants: Atmospheric stability, Stability and plume behavior, Dispersion modeling

Industrial emission reduction: Introduction Concepts, Particulate matter control equipment, Gaseous pollutant control equipment

Text Books/ References:

1. Cooper, C. D., & Alley, F. C. (2010). Air pollution control: A design approach. Waveland Press.
2. Flagan, R. C., & Seinfeld, J. H. (1988). Particle formation in combustion. Fundamentals of Air Pollution Engineering, 358-390.
3. Cooper, C. D., Dietz, J. D., & Reinhart, D. R. (2000). Foundations of environmental engineering. Waveland Press.
4. Burke, G., Singh, B. R., & Theodore, L. (2005). Handbook of environmental management and technology (No. Ed. 2). John Wiley & Sons, Inc.

ENVIRONMENT & ECOLOGY

SYLLABUS:

Definition, Scope & Importance, Need for Public Awareness- Environment definition, Eco system – Balanced ecosystem, Human activities – Food, Shelter, Economic and social Security. Effects of human activities on environment-Agriculture, Housing, Industry, Mining and Transportation activities, Basics of Environmental Impact Assessment. Sustainable Development.

Natural Resources- Water Resources- Availability and Quality aspects. Water borne diseases, Water induced diseases, Fluoride problem in drinking water. Mineral Resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur Cycles. Energy – Different types of energy, Electro-magnetic radiation. Conventional and Non-Conventional sources – Hydro Electric, Fossil Fuel based, Nuclear, Solar, Biomass and Bio-gas. Hydrogen as an alternative future source of Energy.

Environmental Pollution and their effects. Water pollution, Land pollution. Noise pollution, Public Health aspects, Air Pollution, solid waste management, Current Environmental issues of importance: population growth, climate change and global warming effects, urbanization, automobile pollution. Acid rain, ozone layer depletion, animal husbandry.
Environmental Protection- Role of Government, Legal aspects, Initiatives by Non-governmental Organizations (NGO), Environmental Education, Women Education.

Text Books/ References:

1. Joseph, B. (2005). Environmental studies. Tata McGraw-Hill Education.
2. Manjunath, D. L. (2007). Environmental Studies. Dorling Kindersley.
3. Rajagopalan, R. (2015). Environmental studies: from crisis to cure (No. Ed. 3). Oxford University Press.
4. Rao, P. V. (2006). Principles of Environmental Science and Engineering. PHI Learning Pvt. Ltd.
5. Meenakshi, P. (2012). Elements of environmental science and engineering. PHI Learning Pvt. Ltd..

GREEN TECHNOLOGY

SYLLABUS:

The twelve Principles of Green Chemistry and green engineering with examples. Green chemistry metrics- atom economy, E factor, reaction mass efficiency and other green chemistry metrics, application of green metrics analysis to synthetic plans.

Waste – sources of waste, different types of waste, chemical, physical and biochemical methods of waste minimization and recycling.

Pollution – types, causes, effects and abatement.

Environmentally benign processes- alternate solvents- supercritical solvents, ionic liquids, water as a reaction medium, energy efficient design of processes- photo, electro and sono chemical methods, microwave assisted reactions.

Green reagents and catalysis in green synthesis.

Designing green processes- safe design, process intensification, in process monitoring.

Safe product and process design – Design for degradation, Real-time Analysis for pollution prevention, inherently safer chemistry for accident prevention.

Industrial case studies.

Text Books/Reference Books:

1. Lancaster, M. (2016). Green Chemistry 3rd Edition: An Introductory Text. Royal society of chemistry.
2. Constable, D. J. (2018). Green Chemistry Metrics. Green Metrics.
3. Manahan, S. (2017). Environmental chemistry. CRC press.

MICRO AND SMART SYSTEMS

SYLLABUS:

Introduction: Glimpses of Microsystems; scaling effects, Smart materials and systems: an overview, Microsensors, Micro actuators, Microsystems, Examples of smart systems: structural health monitoring and vibration control.

Microfabrication Process: Structure of silicon and other materials, Silicon wafer processing; Thin-film deposition, Lithography, wet etching and dry etching, Bulk micromachining and Surface micromachining, Wafer-bonding; LIGA and other moulding techniques, Soft lithography and polymer processing, Thick-film processing; Low temperature co-fired ceramic processing, Smart material processing.

Mechanics of Solids: Stresses and deformation: bars and beams, Microdevice suspensions: lumped modeling, Residual stress and stress gradients, Poisson effect; Anticlastic curvature; examples of micromechanical structures, Thermal loading; bimorph effect, Dealing with large displacements; in-plane and 3D elasticity equations, Vibrations of bars and beams, Gyroscopic effect, Frequency response; damping; quality factor. Basic micro-flows for damping calculation

Finite element method: Types of numerical methods for solving partial differential equations, variational principles, Weak form; shape functions, Isoparametric formulation and numerical integration, Implementation of the finite element method, FEM for piezoelectrics.

Electronics and packaging: Semiconductor devices: basics, OpAms and OpAmp circuits, Signal conditioning for microsystems devices, Control and microsystems, Vibration control of a beam, Integration of microsystems and microelectronics, Packaging of Microsystems: why and how, Flip-chip, ball grid, etc.; reliability, Case-study 1 (Pressure sensor), Case-study 2 (Accelerometer).

Text Books/ References:

1. Senturia, S. D. (2007). Microsystem design. Springer Science & Business Media.
2. Hsu, T. R. (2008). MEMS and microsystems: design, manufacture, and nanoscale engineering. John Wiley & Sons.
3. Varadan, V. K., Vinoy, K. J., & Gopalakrishnan, S. (2006). Smart material systems and MEMS: design and development methodologies. John Wiley & Sons.

ENTREPRENEURSHIP AND STARTUPS

SYLLABUS:

Entrepreneurship: An Overview of Entrepreneurs and Entrepreneurship, Starting Your Small Business, Forms of Ownership, Becoming an Owner, Planning, Organizing, and Managing, Obtaining the Right Financing, Developing Marketing Strategies, Promotion and Distribution, Managing Human Resources, Employee Relationships, Basic Financial Planning.

Startup: Introduction to startups, Customer Discovery, Opportunity Assessment, Business Models, Entrepreneur talk, Sector Specific Group Briefing by Advisory Committee, Corporate Legal and Intellectual Property, Pitching, Payers and Reimbursement, Pitch practice, Investors, Mistakes I Won't Repeat in business, Business Development and Exits, Finance, Budgeting, Team Building, Pitch Competition for Slot at Investor Night, Pitch Night.

Text Books and References:

1. Megginson, W. L., Byrd, M. J., & Megginson, L. C. (2000). Small business management: an entrepreneur's guidebook. Irwin/McGraw-Hill.
2. Meyer, M. H., & Crane, F. G. (2013). New Venture Creation: An Innovator's Guide to Entrepreneurship. Sage Publications.
3. Meyer/Crane text: Page 8-15, Chapter 1, Are You Suited for Entrepreneurship?
4. Video: Noam Wasserman, Harvard Business School, Surprising facts from Founder's.
5. Wasserman, N. (2012). The founder's dilemmas: Anticipating and avoiding the pitfalls that can sink a startup. Princeton University Press.