Course Contents

Semester-I Courses

TE 601 Computational Methods in Engineering 3-1-0

Course Content

Introduction to Computational Methods, Non-Linear Equations, Linear Equations, Solution of a Set of Non-linear Equations, Interpolation and regression, Numerical Differentiation, Numerical Integration, Ordinary Differential Equation, Partial Differential Equations in Thermal and Fluids. Classification of Partial Differential Equations, Common Elliptic Equations and their numerical Solutions, Solution of Parabolic Equations, Solution of Hyperbolic Equations using finite difference methods, Introduction to Navier Stokes Equations, Solution of Parabolised Navier-Stokes Equations, Introduction to Control Volume Methodology, Application of Control Volume methodology for Navier-Stokes equations, Artificial Compressibility Method, Grid-Generation.

Text/References:

- Joe D. Hoffman, Steven Frankel, Numerical Methods for Engineers and Scientists, Second Edition, McGraw Hill, New York,1992
- D. Vaughan Griffiths, I.M. Smith, Numerical Methods for Engineers, Second Edition CRC Press, Taylor & Francis
- G. Miller ,Numerical Analysis for Engineers and Scientists, Cambridge University Press, New York
- Steven C. Chapra, Raymond P. Canale, Numerical methods for engineers: with software and programming applications, McGraw-Hill, 2002

TE 602 Advanced Thermodynamics & Combustion 3-1-0

Course Content

Properties of Pure Substances: Phase change process of pure substances, PVT surface, P-V & P- T diagrams, Use of steam tables and charts in common use. Laws of thermodynamics: 2nd law Analysis for Engg. Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure substances, T-ds relations, entropy generation, thermo electricity, Onsager equation. Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction, Third law of thermodynamics, Nerst heat theorem and thermal death of universe. Thermodynamic Property Relations: Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and C_v and C_p, Joule Thomson Coefficient, Δh, Δu, Δs of real gases. Combustion Technology: Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about K_p of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of K_p with Temperature, Phase equilibrium,

Text/References:

- Thermodynamics – An Engineering Approach, Yunus Cengel and Michael Boles,7th Ed., Tata McGraw Hill
- Modern Engineering Thermodynamics, Robert Balmer, Elseveir.
- Advanced Thermodynamics for Engineers, Winterbone, John Wiley
- Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill

TE 603 Advanced Heat and Mass Transfer 3-1-0

Course Content

Introduction; General Equation of Heat Conduction; 1-D and 2-D steady conduction –analytical approach; Unsteady conduction; Numerical approach to conduction problems; Introduction to convection; Conservation equations for mass, momentum and energy; Internal and external laminar forced convection; Natural convection; Effect of turbulence on convective heat transfer; Heat Exchangers – basic principles and design; Introduction to Radiation; Spectral and directional nature of surface radiation; Kirchhoff's law and gray surface approximation; View factor; Radiation exchange between black and diffuse gray surfaces in an enclosure; Introduction to radiation in participating media; Introduction to Boiling and Condensation; Introduction to Mass Transfer; Conservation of species equations; Mass diffusion with/without homogeneous chemical reactions.

Text/References:

- S. P. Sukhatme, Heat Transfer, 4th Edition, University Press, 2005.
- F. P. Incropera and D. P. Dewitt, Fundamentals of Heat and Mass Transfer, 5th Edition, John Wiley and Sons, 2004.
- P. S. Ghoshdastidar, Heat Transfer, Oxford, 2004.

TE 604 Advanced Fluid Mechanics 3-1-0

Course Content

Fluid Kinematics; Concepts of system and control volume analyses, Reynolds Transport Theorem, Mass, Momentum and Energy conservation equations (Integral and Differential forms);
Potential flow; Basic potential flows and their combinations.
Viscous Flow: Navier-Stokes equations, Exact solutions to Navier-Stokes equations, Hagen-Poiseulle flow, Poiseulle flow and Couette flow, straight flow through an Annulus
Boundary Layer Flow, Von-Karman momentum-integral equation, Laminar and Turbulent boundary-layer flows; Boundary Layer separation,
Compressible flow: Concepts of stagnation states, Mach number and Isentropic flow; flow with area change, Normal Shock, Rayleigh flow and Fanno flow, Introduction to Bio Fluids.

Text/ References:

- B.R.Munson, D.F.Young and T.H.Okiishi., Fundamental of Fluid Mechanics, John Wiley and Sons., 1994.
- H.Schlichting, Boundary Layer Theory, McGraw-Hill Series in Mechanical Engineering, 1979.
- F.M.White, Fluid Mechanics, McGraw-Hill international editions., 1994.
- Fox. Mc Donald & Pritchard, Fluid Mechanics, Wiley India Pvt. Ltd. New Delhi, 2012

TE609 Design of Thermal Systems 3-1-0

Course Content

Introduction to Thermal Systems and Design, Formulation of Design Problems, Design variables and constraints, Modeling, Simulation and Optimization.
Modeling and its Importance in System Design, Types of Modeling, Modeling of Thermodynamic and some typical Thermal Systems. Curve fitting.
Systems Simulation: Importance of simulation, Methods of Simulation. Information flow diagram. Successive-substitution method and Newton- Raphson Method of numerical Simulation, Design of Thermal Systems from different application areas,
Economic Analysis: Interest and its calculation, Investment economics , Taxes and Depreciation ,applications to Thermal Systems,
System Optimization: Importance of Optimization in Thermal System Design, Objective function and Constraints, Mathematical Formulation of Optimization Problems, Optimization Techniques, calculus method, Lagrange- Multipliers method, Geometric programming, Unconstrained and Constrained Optimizations, Concept of Artificial Neural Network (ANN) Technique and Case studies.

Text /References:

- Y. Jaluria, Design and Optimization of Thermal Systems, McGraw Hill, 1998, Indian Reprint, 2013, Yes Dee Publishing Pvt. Ltd. Chennai-58, India
- W.F. Stoecker, Design of Thermal Systems, McGraw Hill, 1981.
- Bejan, Tsatsaronis and Moran, Thermal Design and Optimization ,Wiley, 1995
- R.F. Boehm, Design and analysis of Thermal Systems, John Wiley, 1987

TE610 Computational Fluid Dynamics 3-1-0

Course Content

A brief overview of the conservation equations for fluid flow and heat transfer, specification of boundary conditions, classification of partial differential equations and pertinent physical behaviour, parabolic, elliptic and hyperbolic equations. Common methods of discretisation: an overview of finite difference equations, finite element and finite volume methods. Numerical solution of parabolic partial differential using finite difference and finite volume methods: explicit, implicit schemes and semi-implicit, consistency, stability and convergence.
The finite volume method of discretization for one dimensional, steady diffusion problems, discretization of transient one dimensional diffusion problems. Discreatization for multiple dimensional diffusion problems. Solution of discrete equations using point and line iteration methods.
Convection diffusion problems: Central difference, upwind, exponential, hybrid and power-law scheme, QUICK scheme and concept of false diffusion. Numerical solution of the Navier-Stokes system for incompressible flows: stream function, vorticity and artificial compressibility methods, requirement of a staggered grid. Simulation of incompressible flow by SIMPLE method. Introduction to the use of commercial software, case studies.

Texts/ References:

- Versteeg H.K. and Malalasekera W, “An Introduction to Computational Fluid Dynamics” Pearso

- Anderson DA, Tanhehill J C and Pletcher R H, "Computational Fluid Mechanics and Heat Transfer", Hemisphere
- Jiyuan Tu, Guan-Heng Yeoh and Chaoqun Liu, "Computational Fluid Dynamics –A Practical Approach" Elsevier
- Patankar S.V., Numerical Heat Transfer and Fluid Flow, Taylor & Francis
- Ferziger, J.H. and Peric, M., Computational Methods for Fluid Dynamics, Springer.

Elective-I

TE 605 Advanced Energy Conversion Systems 3-1-0

Course Content

Hydrogen Energy; hydrogen production, Storage of hydrogen, delivery, conversion, applications, present status. Clean Coal technologies:, Pressurized fluidized bed combustion, gasification etc., Integrated gasification combined cycle plant. Coal bed methane. Fuel Cell, Principles, classification of fuel cells, working of different types of fuel cells, fuels for fuel cells, relative performances of various fuel cells, efficiency, V-I Characteristics of fuel cell, fuel cell power plant. Natural gas cycles: Gas turbine cycles, combined& mixed cycle power plant with cogeneration, fuels for combined cycle power plants. Energy systems for industry: Integrated power generation. Cogeneration principles. Energy conservation in power plant: Energy conservation opportunities in power plants, economic and environmental aspects of energy conservation in power plants, economic load sharing of power plants, Advanced energy storage systems.

Text /References:

- Energy Conversion Systems,R. D. Begamudre, New Age, 2000
- M.M. EL-Halwagi, Biogas Technology- Transfer and diffusion, Elsevier Applied science Publisher, New York, 1984.
- Fuel Cells, by W. Vielstich, translated by D. J. G. Ives, Willey Interscience, 1965.
- Microbial Fuel Cells, by B. E. Logan, John Willey & Sons, 2008.
- I. Boustead and G. F. Hancock, Handbook of Industrial Energy Analysis, Ellis Horwood Ltd., A division of John Wiley and Sons, 1979.

TE 606 Internal Combustion Engines 3-1-0

Course Content

Thermodynamics of fuel-air cycles, real cycles; Unburned and burned gas mixture charts; Ignition, normal and abnormal combustion in SI and CI engines; Conventional and alternative fuels for engines; Conventional and electronic fuel management systems for SI and CI engines; Design of combustion chamber for SI and CI engines; Engine emissions; Lubrication; Cooling; Supercharging and Turbocharging; Modern developments in IC engines.

Text/References:

- Heinz Heisler, 'Advanced Engine Technology," SAE International Publications,USA,1998
- Ganesan V. ." Internal Combustion Engines" , Third Edition, Tata Mcgraw-Hill ,2007
- John B Heywood," Internal Combustion Engine Fundamentals", Tata McGraw-Hill 1988
- Patterson D.J. and Henein N.A,"Emissions from combustion engines and their control," AnnArbor Science publishersInc,USA,1978
- Gupta H.N, "Fundamentals of Internal Combustion Engines" ,Prentice Hall of India, 2006

- Ultrich Adler ," Automotive Electric / Electronic Systems, Published by Robert Bosh GmbH,1995

TE 607 Waste Heat Recovery Systems 3-1-0

Course Content

Introduction: Principles of thermodynamics, cycles, topping, bottoming, combined cycle, organic rankine cycles, performance indices of cogeneration systems, waste heat recovery, sources and types, concept of tri-generation. Configuration and thermodynamic performance, steam turbine cogeneration systems, gas turbine cogeneration systems, reciprocating IC engines cogeneration system, combined cycles cogeneration systems, advanced cogeneration systems: fuel cell, Stirling engines etc., Waste Heat Recovery: Classification, Advantages and applications, Commercially viable waste heat recovery devices, Saving potential.

Text/References:

- Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics,Oxford, 1987.
- Institute of Fuel, London, Waste Heat Recovery, Chapman and Hall Publishers,London, 1963
- Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
- Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management,Hemisphere, Washington, 1983.
- De Nevers, Noel, Air Pollution Control Engineering, McGrawHill, New York,1995.

<u>Elective-II</u>

TE611 Turbomachinery 3-1-0

Course Content

Revision of fundamentals. Types of turbomachines and their applications. Dimensional analysis and performance parameters. Cascade theory: types of cascades, flow and geometric parameters, boundary layer development. Wind tunnels: types, designs, construction features and instrumentation. Axial flow turbines, axial flow compressors, propellers, centrifugal fans,
Blowers and Compressors – fluid flow, types of blading, velocity triangles, diffusers and nozzles, pressure change, multi-staging, stall, enthalpy-entropy diagram, efficiency, acoustics, applications. Wind turbines – types, analysis, site, atmospheric aspects. Solar plant turbines: principles, construction features and performance. Future trends.

Text/References:

- S.M. Yahya, "Turbine, Compressors and Fans", Tata McGraw Hill Co. New Delhi, 1998.
- V. Ganesan, "Gas Turbines", Tata McGraw Hill Co. New Delhi, 2001.
- D.G. Sheperd, "Principles of turbomachinery", The Macmillan Company, New York.
- A. H.Church and JagadishLal, "Centrifugal Pumps and Blowers", Metropolitan Book Co. 1973
- A.J. Stepanoff, "Centrifugal and Axial Flow Pumps", Wiley and sons, 1966.

TE 612 Design of Heat Exchangers 3-1-0

Course Content

Applications. Basic design methodologies – LMTD and effectiveness-NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor.

Classification and types of heat exchangers and construction details. Design and rating of double pipe heat exchangers, compact heat exchangers, plate and heat pipe type, condensers, cooling towers. Heat exchanger standards and testing, Heat transfer enhancement and efficient surfaces. Use of commercial software packages for design and analysis, optimization.

Text/References:

- Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002
- Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
- Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
- Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994

TE 613 Gas Dynamics and Jet Propulsion 3-1-0

Course Content

Recapitulation of fundamentals, introduction to numerical analysis of compressible flow. Oblique shocks, compression and expansion waves, Prandtl Meyer expansion. Interaction of shock waves and shock boundary layer interaction. Flow with friction and heat transfer. Introduction to 1-D transient and 2-D compressible flow. Method of characteristics. Applications in measurement of subsonic and supersonic flows, wind tunnels, medical, aircraft and rocket propulsion. Introduction to hypersonic, high-temperature flows and astro gas dynamics.

Text/References:

- E. Radhakrishnan, Gas Dynamics, PHI, 2000. 2nd Edition.
- SL. Somasundaram, Gas dynamics and jet propulsion
  Ganesan. V, Gas Turbines, TMH, 1999
- Ascher.H. Shaporo, The Dynamics and Thermodynamics of Compressible Flow Vol I and Vol II The Ronald Press. Co, NY 1995.
- Cohen H. Rogers & Sravanamutoo, Gas Turbine Theory, Addison Wiley, 1987

TE 614 Experimental Methods in Thermal Engineering 3-1-0

Statistics: Distributions, estimators, confidence levels, sample size, test of hypothesis, Goodness-of-fit test Chauvenet's criteria; Regression analysis, co-relations. Uncertainty analysis. Design of experiments. Instruments: Specifications. Static and dynamic characteristics. Instruments for measuring distance, profile, pressure, temperature, velocity, flow rate, level, speed, force, torque, noise, chemical analyses. Estimation of systematic errors. Signal conditioning, data acquisition and analysis. Transducers, A-D & D-A convertors, interfacing with computers and PLCs. Control theory fundamentals: Steady state and transient response, Stability analysis Routh and Nyquist criteria, Root locus method. Use of various controllers and actuators. Data management and presentation.

Text/References:

- C. V.Coilete & Hope, Engineering Measurements, 2nd ed. Elbs.
- Beckwith. N. Lewis ,Marargonj, Mechanical measurements, Narosa Publishing House 2008, 6th Edition, New Delhi.

- I.J. Nagrath, Gopal, Control System Engineering, New Age International Publications, 2007, 5th Edition.
- J.P Hollman, Experimental Methods for Engineers, 6th Ed. MGH
- Sirohi & Radhakrishnan Mechanical Measurement, New Age International (P) Ltd., 2005, 3rd Edition.
- A. K. Sawhney, Mechanical Measurements and Instrumentation, Dhanpat Rai & company (P) ltd, 2007, 12th edition

Elective-III

TE 615 Process Analysis and Optimization 3-1-0

TE 616 Steam & Gas Turbines 3-1-0

Course Content

Introduction, thermodynamics and fluid dynamics of compressible flow through turbines. Recapitulation of heat cycles of steam power plants and gas turbine engines. Application of CFD in turbines. Energy conversion in a turbine stage. Geometrical and gas dynamic characteristics of turbine cascades. Turbine cascades and losses in turbine stage efficiency. Multi-stage turbines, radial turbines, partial admission turbines, turbines for nuclear power plants. Steam turbines for co-generation, supercritical and marine applications. Steam and gas turbine components. Governing of steam and gas turbines. Strength and vibration aspects. Steam and gas turbines of major manufacturers. Future trends.

Text/References:

- Steam Turbines for Modern Fossil-Fuel Power Plants – A.S. Leyzerovich.
- Gas Turbines, A Handbook of Air, Land and Sea Applications – Claire Soares.
- Gas Turbine Performances—P.P. Walsh & P. Fetcher
- Micro Turbines -- Claire Soares
- Blade Design and Analysis for Steam Turbines – Ronald H. Aungier
- Turbine Aerodynamics: Axial-Flow and Radial-Flow Turbine Design and Analysis --Ronald H. Aungier

TE 617 Heating, Ventilation & Air-conditioning 3-1-0

Course Content

Introduction. Environmental impact of refrigerants. Analysis of VCR cycles–multistage, multi-evaporator, cascade systems, supercritical and other advanced cycles. Properties and selection of pure and mixed refrigerants. Properties of binary mixtures. Analysis of vapor absorption cycles–Aqua ammonia and LiBr water cycles. Air cycle refrigeration, vortex tube, steam jet ejector refrigeration, thermoelectric refrigeration, cryogenics, desiccant cooling–solid and liquid systems, hybrid systems, heat pumps and heat transformers.

Text/References:

- Stoecker, W. F. and Jones, J. W., Refrigeration and Air-Conditioning, TMH Edition, 2001
- Arora, C. P., Refrigeration and Air-conditioning, TMH Edition, 2003.
- Roy J. Dossat, Principles of Refrigeration, 4th Edition, Prentice Hall of India (P) Ltd, 2004