JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech. (THERMAL ENGINEERING)

EFFECTIVE FROM ACADEMIC YEAR 2019- 20 ADMITTED BATCH

R19 COURSE STRUCTURE AND SYLLABUS

I Year I Semester

Course Code	Course Title	L	T	P	Credits
Professional Core - I	Advanced Thermodynamics	3	0	0	3
Professional Core - II	Advanced Fluid Mechanics	3	0	0	3
Professional Elective - I	1. Fuels & Combustion 2. Alternate Fuels & Pollution 3. Advanced Fuel Cell Technologies	3	0	0	3
Professional Elective - II	1. Computational Fluid Dynamics 2. Turbulence Modelling 3. Nano Fluids	3	0	0	3
	Research Methodology & IPR	2	0	0	2
Lab - I	Computational Methods Lab	0	0	4	2
Lab - II	Advanced Fluid Mechanics Lab	0	0	4	2
Audit - I	Audit Course - II	2	0	0	0
	Total	**16**	**0**	**8**	**18**

I Year II Semester

Course Code	Course Title	L	T	P	Credits
Professional Core - III	Advanced I.C. Engines	3	0	0	3
Professional Core - IV	Advanced Heat and Mass Transfer	3	0	0	3
Professional Elective - III	1. Advanced Finite Element and Boundary Element Methods 2. Optimization Techniques & Applications 3. Numerical Methods for Engineers	3	0	0	3
Professional Elective - IV	1. Thermal & Nuclear Power Plants 2. Renewable Energy Sources 3. Energy Conservation & Management	3	0	0	3
	Mini Project with Seminar	0	0	4	2
Lab - III	Advanced I.C. Engines Lab	0	0	4	2
Lab - IV	Advanced Heat & Mass Transfer Lab	0	0	4	2
Audit - II	Audit Course - II	2	0	0	0
	Total	**14**	**0**	**12**	**18**

II Year I Semester

Course Code	Course Title	L	T	P	Credits
Professional Elective - V	1. Advanced Refrigeration & Air-Conditioning 2. Convective Heat Transfer 3. Advanced Materials for Thermal Systems	3	0	0	3
Open Elective	Open Elective	3	0	0	3
Dissertation	Dissertation Work Review - II	0	0	12	6
	Total	**6**	**0**	**12**	**12**

II YEAR II - SEMESTER

Course Code	Course Title	L	T	P	Credits
Dissertation	Dissertation Work Review - III	0	0	12	6
Dissertation	Dissertation Viva-Voce	0	0	28	14
	Total	**0**	**0**	**40**	**20**

***For Dissertation Work Review - I, Please refer 7.8 in R19 Academic Regulations.**

Audit Course I & II:

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

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

ADVANCED THERMODYNAMICS (Professional Core - I)

Prerequisites: Thermodynamics

Course Objectives: The course is intended to

- Provide analytical methods for the determination of the direction of processes from the first and second laws of thermodynamics and to Introduce methods in using equations of potentials, availability, and excergy for thermodynamic analysis
- Gain the knowledge on non-reactive mixture properties, Psychometric Mixture properties and psychometric chart and Air conditioning processes
- Develop the ability of analyzing vapor and Gas power cycles
- Provide in depth knowledge of Direct Energy Conversion of Fuel Cells, Thermo electric energy, Thermionic power generation, Thermodynamic devices Magneto Hydrodynamic Generations and Photo voltaic cells
- Develop communication and teamwork skills in the collaborative course project

Course Outcomes: At the end of the course, the student will be able to:

- Explain basic thermodynamic concepts and laws
- Describe the concepts entropy and excergy and their use in analyses of thermal energy systems
- Analyze power plants, refrigeration plants and thermal/chemical installations
- Evaluate means for minimizing excergy losses in selected processes
- Use advanced thermodynamics on a research case

UNIT - I

REVIEW OF THERMODYNAMIC LAWS AND COROLLARIES: Transient flow analysis, Second law of thermodynamics, Entropy, Availability and unavailability, Thermodynamic potential. Maxwell relations, Specific heat relations, Mayer's relation. Evaluation of thermodynamic properties of working substance

UNIT- II

P.V.T SURFACE: Equation of state. Real gas behavior, Vander Waal's equation, Generalization compressibility factor. Energy properties of real gases. Vapour pressure, Clausius-Clapeyro equation. Throttling, Joule Thompson coefficient. Non-reactive mixtures of perfect gases. Governing laws, Evaluation of properties, Psychometric mixture properties and psychometric chart, Air conditioning processes, cooling towers. Real gas mixture.

UNIT- III

COMBUSTION: Combustion Reactions, Enthalpy of formation. Entropy of formation, Reference levels of tables. Energy of formation, Heat reaction, Adiabatic flame temperature generated product, Enthalpies, Equilibrium. Chemical equilibrium of ideal gases, Effect of non-reacting gases equilibrium in multiple reactions, The Vent Hoff's equation. The chemical potential and phase equilibrium. The Gibbs phase rule.

UNIT- IV

POWER CYCLES: Review binary vapour cycle, co generation and combined cycles, Second law analysts of cycles. Refrigeration cycles, Thermodynamics of irreversible processes. Introduction, Phenomenological laws, Onsager Reciprocity relation, Applicability of the Phenomenological relations, Heat flux and entropy production, Thermodynamic phenomena, Thermo electric circuits.

UNIT- V:

DIRECT ENERGY CONVERSION INTRODUCTION: Fuel cells, Thermo electric energy, Thermo ionic power generation, Thermodynamic devices magneto hydrodynamic generations, Photovoltaic cells.

TEXT BOOKS:

1. Basic and Applied Thermodynamics by P. K. Nag, TMH
2. Engineering Thermodynamics by Rogers & Mayhew, Pearson
3. Thermodynamics by Holman, Mc Graw Hill.

REFERENCE BOOKS:

1. Thermal Engineering by Rathore, TMH
2. Applied Thermodynamics by R.K. Rajput, Laxmi Publications
3. Thermal Engineering by Soman, PHI
4. Engineering Thermodynamics by P. L. Dhar, Elsevier
5. Thermodynamics by Sonnatag & Van Wylen, John Wiley & Sons
6. Thermodynamics for Engineers by Doolittle-Messe, John Wiley & Sons
7. Irreversible Thermodynamics by HR De Groff.
8. Thermodynamics & Heat Power by Granet & Bluestein, CRC Press
9. Engineering Thermodynamics by Chatopadyaya

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

ADVANCED FLUID MECHANICS (Professional Core - II)

Prerequisites: Fluid Mechanics & Hydraulic Machinery

Course Objectives: The course is intended to

- Establish an understanding of the fundamental concepts of fluid mechanics.
- Understand and apply the potential flow equations to basic flows.
- Understand and apply the differential equations of fluid mechanics including the ability to apply and understand the impact of assumptions made in the analysis.
- Understand the boundary layer concepts with respect to fluid flow**.**
- Understand and apply the compressible flow equations.

Course Outcomes: At the end of the course, the student will be able to:

- Understanding the concept of fluid and the models of fluids.
- Understanding the basic physical meaning of general equations.
- Understanding the concept of stream function and potential function.
- Ability to derive the equation for viscous flow, including laminar flow and turbulent flow.
- Ability to address such problems in engineering, and to solve the problems

UNIT-I:

Inviscid Flow of Incompressible Fluids: Lagrangian and Eulerain Descriptions of fluid motion- Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three-dimensional continuity equation- Stream and Velocity potential functions.

Basic Laws of fluid Flow: Condition for irrotationality, circulation & vorticity Accelerations in Carte systems normal and tangential accelerations, Euler's, Bernoulli equations in 3D– Continuity and Momentum Equations

UNIT-II:

Viscous Flow: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poiseuille flow - Coutte flow with and without pressure gradient - Hagen Poiseuille flow - Approximate solutions – Creeping motion (Stokes) – Oseen's approximation.

UNIT-III:

Boundary Layer Theory: Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory - Boundary layer thickness for flow over a flat plate –- Von-Karman momentum integral equation - Blasius solution- Laminar boundary layer – Turbulent Boundary Layer –— Expressions for local and mean drag coefficients for different velocity profiles. – Total Drag due to Laminar & Turbulent Layers – Problems.

UNIT-IV:

Introduction to Turbulent Flow: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations - Prandtl Mixing Length Model - Universal Velocity Distribution Law: Van Driest Model –Approximate solutions for drag coefficients – More Refined Turbulence Models – k-epsilon model - boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders

Internal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

UNIT-V:

Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy - Acoustic Velocity Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State

Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Releigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

Text Books:

1. Fluid Mechanics and Fluid Machines by S K Som and G Biswas, TMH
2. Fluid Mechanics **by** Joseph H Spurk and Nuri Aksel, Springer
3. Compressible Fluid Dynamics by B K Hodge and Keith Koenig, Pearson
4. Fluid Mechanics by Potter, Cengage Learning.
5. Fluid Mechanics and Hydraulic Machines by Dr. R.K. Bansal.

Reference Books:

1. Fluid Mechanics by Jog, Cambridge
2. Fluid Mechanics and Machinery by Khan, Oxford
3. Fluid Mechanics by Cohen and Kundu, Elsevier, 5th edition
4. Fluid Mechanics by William S Janna, CRC Press
5. Dynamics & Theory and Dynamics of Compressible Fluid Flow by Shapiro.
6. Fluid Dynamics by William F. Hughes & John A. Brighton, TMH

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

FUELS AND COMBUSTION (Professional Elective - I)

Prerequisites: Thermodynamics, Thermal Engineering I & II

Course Objectives: The course is intended to make a post graduate student to understand

- The fundamental of combustion phenomena in general
- The different combustion process, its thermodynamics and kinetics
- The combustion mechanism in different types of combustion
- The burner design for efficient combustion
- Different combustion models
- The effect of quantity & quality of fuel and engine technology on exhaust emissions
- The concept of laminar and turbulent flame propagation
- Different methods to reduce air pollution

Course Outcomes: At the end of the course, the student will be able to**:**

- Understand the concepts of combustion phenomena in energy conversion devices
- Apply the knowledge of adiabatic flame temperature in the design of combustion devices
- Identify the phenomenon of flame stabilization in laminar and turbulent flames
- Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels

UNIT–I:

Fuels: Detailed classification – Conventional and Unconventional Solid, Liquid, gaseous fuels and nuclear fuels – Origin of Coal – Analysis of coal.

Coal – Carborisation, Gasification and liquification – Lignite: petroleum-based fuels – problems associated with very low calorific value gases: Coal Gas – Blast Furnace Gas Alcohols and Biogas.

UNIT–II:

Principles of Combustion: Chemical composition – Flue gas analysis – dew point of products – Combustion stoichiometry.

Chemical kinetics – Rate of reaction – Reaction order – Molecularity – Zeroth, first, second and third order reactions - complex reactions – chain reactions. Theories of reaction Kinetics – General oxidation behavior of HC's.

UNIT–III:

Detonation and Deflagration waves of premixed gasses, Rankine Hygienist relation, Hygienist curve, laminar and turbulent flame propagation and structure**,** Burning velocity of fuels – Measurement of burning velocity – factors affecting the burning velocity.

UNIT–IV:

Flame Stability, Combustion of fuel, Theory of diffusion flames, droplets and sprays – Combustion systems – Pulverized fuel furnaces – fixed, Entrained and Fluidised Bed Systems.

UNIT–V:

Environmental Considerations: Air pollution – Effects on Environment, Human Health etc. Principal pollutants – Legislative Measures – Methods of Emission control.

TEXT BOOKS:

1. Combustion Fundamentals by Roger A Strehlow, Mc Graw Hill
2. Fuels and combustion by Sharma and Chander Mohan, Tata Mc Graw Hill

REFERENCE BOOKS:

1. Combustion Engineering and Fuel Technology by Shaha A.K., Oxford and IBH.
2. Principles of Combustion by Kanneth K. Kuo, Wiley and Sons.
3. Fuels & Combustion by Sameer Circar, Mc. Graw Hill.
4. An Introduction to Combustion by Stephen R. Turns, Mc. Graw Hill International Edition.
5. Combustion Engineering by Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

ALTERNATE FUELS AND POLLUTIONS (Professional Elective - I)

Prerequisites: Hydrogen and Fuel Cells, Biodiesel - Production and Properties

Course Objectives:

- Gain knowledge of various alternative fuels
- Know about Natural gas, LPG, hydrogen and bio gas.

Course Outcomes: At the end of the course, the student will be able to:

- Identify the need of alternate fuels and list out some prospective alternate fuels.
- Categorize, interpret and understand the essential properties of fuels for petrol and diesel engines.
- Infer the storage and dispensing facilities requirements.
- Analyze the implement limitations with regard to performance, emission and materials compatibility.
- Identify and understand possible harmful emissions and the legislation standards

UNIT- I:
Need for alternate fuel: Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars.

UNIT- II:
Alcohols: Properties as engine fuel, alcohols and gasoline blends, performance in SI engine, methanol and gasoline blends, combustion characteristics in CI engines, emission characteristics, DME, DEE properties performance analysis, performance in SI & CI Engines.

UNIT- III:
Natural Gas, LPG, Hydrogen and Biogas: Availability of CNG, properties, modification required to use in engines, performance and emission characteristics of wiring CNG & LPG in SI & CI engines. Hydrogen; storage and handling, performance and safety aspects.

UNIT- IV:
Technical Background of Diesel/Bio-diesel fuels-Oil feed stocks- Transesterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing, Bio diesel-Oxidation stability-Performance in Engines, Properties of bio-fuels and their importance in the context of IC Engines. Vegetable Oils: Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics

UNIT- V:
Electric, Hybrid, Fuel Cell and Solar Cars: Layout of an electric vehicle, advantage and limitations, specifications, system components, electronic control system, high energy and power density batteries, hybrid vehicle, fuel cell vehicles, solar powered vehicles.

TEXT BOOKS:

1. Alternate Fuels by Dr. S. S. Thipse, Jaico Publications
2. Alternative Fuels Guide Book by Richard. L & Bechfold, SAE International Warrendale - 1997.

REFERENCE BOOKS:

1. Energy Today & tomorrow by Maheswar Dayal, 1 & B Horishr India-1982.
2. Power Plant Engineering by Nagpal, Khanna Publishers, 1991.
3. Alcohols as motor fuels progress in technology, Series No. 19 - SAE Publication USE - 1980.
4. SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA
5. Alternative Fuels Guidebook by Bechtold R.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

ADVANCED FUEL CELL TECHNOLOGIES (Professional Elective - I)

UNIT- I:
Introduction: Relevance, Principle, various configurations (Alkaline, Acid, Proton Exchange Membrane, direct methanol, molten carbonate and solid oxide fuel cells) fuel cell applications. Basic theory of electrochemistry, electrochemical energy conversion, electrochemical techniques. Thermodynamics of fuel cells. Heat and mass transfer in fuel cells. Single cell characteristics.

UNIT- II:
Modelling: Electrochemical model. Heat and mass transfer model. System thermodynamic model.

UNIT- III:
Low and High Temperature Fuel Cells: Proton exchange membrane fuel cell (PEMFC) and direct methanol fuel cell (DMFC): their special features and characteristics. Molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) for power generation, their special features and characteristics.

UNIT –IV:
Fuels and Fuel Processing: Availability, production and characteristics of Hydrogen, fossil fuel – diverted fuels and biomass- diverted fuels. Principles of design of PEMFC, DMFC and SOFC.

UNIT- V:
Fuel Cell System: Materials, component, stack, interconnects, internal and external reforming, system layout, operation and performance.

TEXT BOOKS:

1. Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. (2007).
2. O' Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).

REFERENCES:

1. J., Dick A., Fuel Cell Systems Explained, 2nd Ed. Wiley, 2003.
2. Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006).
3. Bard, A. J., L. R., Faulkner, Electrochemical Methods, Wiley, N.Y. (2004) Ref Book.
4. M.T.M. Koper (ed.), Fuel Cell Catalysis, Wiley, Larminie 2009.
5. J. O'M. Bockris, A.K.N. Reddy, Modern Electrochemistry, Springer 1998.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

COMPUTATIONAL FLUID DYNAMICS (Professional Elective - I)

Pre-requisite: Heat Transfer, Fluid Mechanics

Course Objective: To apply the principles of Heat Transfer and Fluid Mechanics to solve simple heat transfer and fluid flow problems using different numerical techniques

Course Outcomes: At the end of the course, the student should be able to

- Differentiate between different types of Partial Differential Equations and to be able to apply appropriate numerical techniques
- Solve the simple heat transfer and fluid flow problems using different numerical techniques
- Understand and to appreciate the need for validation of numerical solution

UNIT-I:
Review of Governing Equations in Heat Transfer and Fluid Flow: Conservation Laws – Differential Form of Equations – Characteristics of Governing Equations - Solution Methods : Analytical, Experimental and Numerical Methods – Review of Boundary Conditions
Introduction to Numerical Methods - Brief about Finite Difference, Finite Element and Finite Volume Methods – Solution of Linear Algebraic Equations – Direct and Iterative Approaches
Mathematical Behavior of Partial Differential Equations: Classification of Partial Differential Equations – Illustrations
Finite Difference Method: Taylor's series – Derivation of Finite Difference Formulae for Partial Derivative Terms - FD formulation of 1D Elliptic PDEs - 1D steady state heat transfer problems – Cartesian, cylindrical and spherical co-ordinate systems –- boundary conditions

UNIT-II:
Finite Difference Method : 2D Elliptic PDEs – 2D Steady State Heat Conduction Problems.
Parabolic PDEs - Transient heat conduction – Errors and Stability - Explicit Method – Stability Analysis – Implicit and Crank Nickolson method – 2-D Parabolic PDEs - Finite Difference formulation – ADI Method and explicit Method – Finite Difference Formulation of 1D Hyperbolic PDEs - Wave Equation

UNIT-III:
Finite Volume Method: Formation of Basic rules for Finite Volume approach – General Nodal Equation - Interface Thermal Conductivity -– Treatment of Source Term and Treatment of Nonlinearity.
Solution of 1D and 2D Elliptic PDEs - Heat conduction problems - Solution of 1D Parabolic PDEs – Explicit Method and Implicit Methods- Transient Heat conduction problems

UNIT-IV:
FVM to Convection and Diffusion: General Form of Governing Equations for Fluid Flow and Heat transfer – Burger's equation - Steady 1D Convection Diffusion – Discretization Schemes and their assessment – Treatment of Boundary Conditions

UNIT-V:
Calculation of Flow Field: Vorticity & Stream Function Method – Advantages and Disadvantages – Treatment of Boundary Conditions - Staggered Grid as Remedy for representation of Flow Field - Pressure Velocity Coupling - SIMPLE & SIMPLER (revised algorithm) Algorithms.
Compressible Flows: Introduction - Pressure, Velocity and Density Coupling.

TEXT BOOKS:

1. Numerical heat transfer and fluid flow – S.V. Patankar (Hemisphere Pub. House)
2. An Introduction to Computational Fluid Dynamics – FVM Method – H.K. Versteeg, W. Malalasekhara (PHI)
3. Computational Fluid Flow and Heat Transfer by Muralidharan & Sundarajan (Narosa Pub)
4. Computational Fluid Dynamics and Heat Transfer by P. S. Ghoshdastidar, Centage Pub

REFERENCE BOOKS:

1. Computational Fluid Dynamics by Hoffman and Chiang, Engg Education System
2. Computational Fluid Dynamics by Anderson, TMH
3. Computational Methods for Fluid Dynamics by Ferziger, Peric, Springer
4. Computational Fluid Dynamics by T.J. Chung, Cambridge University
5. Computational Fluid Dynamics by A Practical Approach – Tu, Yeoh, Liu, Elsevier
6. Text Book of Fluid Dynamics by Frank Chorlton, CBS Publishers

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

TURBULENCE MODELLING (Professional Elective - II)

Prerequisites: Thermodynamics 1 & 2

Course Objectives: The course is intended to

- Understand the fundamental concepts of turbo machines
- Apply concepts of fluid mechanics in turbo machines.
- Understand the thermodynamic analysis of steam nozzles and turbines.
- Understand the different types of compressors and evaluating their performances in the form of velocity triangles.
- Familiarize the basic concepts of gas dynamics and analyze the performance of axial flow gas turbines

Course Outcomes: At the end of the course, the student will be able to:

- To design and analyze the performance of Turbo machines for engineering applications
- To understand the energy transfer process in Turbo machines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbo machines.
- To design various Turbo machines for power plant and aircraft applications
- Understand the design principles of the turbo machines
- Analyze the turbo machines to improve and optimize their performance

UNIT-I:
Introduction and Origin Of Turbulence: Properties of laminar flow, Properties of turbulent flow. Boundary Layer: Boundary Layer, Growth rate of Boundary layer for Laminar and Turbulent Flows. Characteristics of Turbulent Flow: The Origin of Turbulence, Nature of Turbulence, Swirling Structure, Mean Motion and Fluctuations, Consequences of Turbulence, Homogeneous Isotropic Turbulence.
Correlation Functions, Kolmogorov Hypothesis and Probability Density Function: Correlation Functions, Ideas about eddy size, Intensity of Turbulence or Degree of Turbulence. Kolmogorov Hypothesis and Energy Cascade: Kolmogorov Universal Law for the Fine Structure, Energy Cascade, Kolmogorov Length Scale, Kolmogorov's First Hypothesis, Kolmogorov's Second Hypothesis. Probability Density Functions and Averaging: Introduction, Probability density function, averaging used in the analysis of turbulent flows.

UNIT -II:
Reynolds Averaged Navier-Stokes Equations and Classical Idealization Of Turbulent Flows: Reynolds' Decomposition, Examples of Turbulent Fluctuations, some Measurements on Fluctuating Components. Measurements on Fluctuating Components: Shear Stress due to the Fluctuations, The boundary layer measurements of Klebanoff. Turbulent Boundary Layer Equations: Turbulent Boundary Layer Equations for a two-dimensional flow. Classical Idealization of Turbulent Stresses: Introduction, The boussines or eddy viscosity model, Eddy viscosity.

UNIT-III:
Vorticity Dynamics: Introduction, Vorticity and the equations of motion, Reynolds stress and vorticity. Vortex Stretching. The Vorticity Equation, Vorticity in Turbulent Flows.
Dynamics of Turbulent Kinetic Energy and Important Scaling Relations: Kinetic Energy of the Mean Flow. Kinetic Energy of Fluctuations. Scaling Relations.

UNIT-IV:

Wall Bounded Flows and Free Shear Flows: The Law of the Wall for Wall Bounded Flows, The Universal Velocity Profile. Free Shear Flows, Turbulent Jets, Uniform Eddy Viscosity model.

Spectral Dynamics: Correlation Functions and Spectra. Correlation Functions and Spectra.

Large - Eddy Simulation of Turbulent Flows: RANS Equations and Eddy Viscosity: Introduction Reynolds Averaged Navier-Stokes (RANS) Equations, Eddy Viscosity Models, Zero-Equation Models. One-Equation Model: One-Equation Model, Two-Equation Model. Two Equation Models: k - ω Model, SST (Shear Stress Transport) Turbulence Model. Discussion on Applicability

UNIT-V:

Large - Eddy Simulation of Turbulent Flows: Low Reynolds number k - ε model: Special Features of Near Wall Flow, Near Wall Treatment in Transport Equation based Models, Wall Function Approach, Low Reynolds number version of k - ε model: Asymptotic Consistency, Damping Functions. RNG k - ε Model and Kato-Launder Model. The Realizable k - ε Model, Reynolds Stress Models (RSM), Large Eddy Simulation (LES). Mathematical Modeling of Turbulent Flows: The Filtered Navier-Stokes Equations, Subgrid Scale Closure, Standard Subgrid-Scale Model. Dynamic Model of LES. Direct Numerical Simulation.

TEXT BOOKS:

1. A First Course in Turbulence by H. Tennekes and J.L. Lumley, 1987, The MIT Press, Cambridge, Massachusetts, and London, England.
2. Fluid Mechanics by P.K. Kundu and I.M. Cohen, 2002, Academic Press (An Imprint of Elsevier Science, USA.

REFERENCE BOOKS:

1. Turbulent Flows by S.B. Pope, 2000, Cambridge University Press, UK.
2. Turbulent Flows: Fundamentals, Experiments and Modeling by G. Biswas and V. Eswaran, 2002, Narosa Publishing House, New Delhi, India.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

NANO FLUIDS (Professional Elective - II)

Prerequisites: Fluid Mechanics, Thermodynamics

Course Objectives: The course is intended to

- Understanding of superior thermo physical properties of nanofluids**.**
- Understanding of synthesis of nanofluids**.**
- Comparison of heat transfer using nanofluids with conventional fluids**.**
- Understanding of convection and boiling heat transfer**.**
- Research on this new topic to design modern mini and micro channel heat exchangers with nanofluids exhibiting much higher thermal efficiency and saving energy

Course Outcomes: At the end of the course, the student will be able to:

- To introduce the application of nanotechnology in the area of fluids and thermal engineering

UNIT- I:
Introduction to nanofluids, nanostructure materials, base fluids, dispersion, sonication and stable suspension. Various types of nanofluids-volumetric concentration. Thermophysical properties: Density; principles of measurement and apparatus. Theoretical equations and new empirical correlations to determine the density of different nanofluids. Viscosity: principles of measurement and apparatus. Andrade's and other theoretical equations and new empirical correlations to determine the viscosity of different nanofluids. Effect of volumetric concentration and temperature. Effect of subzero temperature on nanofluid viscosity.

UNIT- II:
Thermal conductivity: principles of measurement and apparatus. Hamilton-Crosser and other theoretical equations and new empirical correlations to determine the thermal conductivity of different nanofluids. Effect of volumetric concentration and temperature. Effect of Brownian motion on enhancing the thermal conductivity. Specific heat: principles of measurement and apparatus. Buongeorno's thermal equilibrium equation and other theoretical equations and new empirical correlations to determine the specific heat of different nanofluids. Effect of volumetric concentration and temperature.

UNIT- III:
Combined effects of thermophysical properties of nanofluids on the thermal diffusivity, the Prandtl number, the Reynolds number and the Nusselt number. Basic understanding of their effects on frictional loss and Heat transfer. Convective heat transfer: Single-phase fluid equations, laminar flow, entry length and fully developed friction factor and heat transfer coefficient. Graetz number effect in the entry region. Correlations for friction factor and Nusselt number for nanofluids. Turbulent flow: Single phase fluid fully developed flow Dittus-Boelter and Glienilski equations. Blasius and other turbulent friction factor correlations. Their comparison with nanofluids data. New correlations for turbulent friction factor and Nusselt number for nanofluids.

UNIT- IV:
Principles of measurement and apparatus for the nanofluid convective heat transfer coefficient. Recent empirical relations for convection coefficient of various types of nanofluids. Effect of particle Peclet number. Effect of volumetric concentration. Application of nanofluids to various types of industrial heat exchangers. Heating capacity, mass flow, heat exchanger surface area, LMTD and pumping power for nanofluids versus conventional heat transfer fluids.

UNIT- V:

Application to building heating and cooling Comparison of nanofluids performance with glycol solution in hydronic coils. Application to automobile radiators. Comparison of the performance of nanofluids under arctic and sub-arctic temperatures with glycol solutions. Introduction to electronic cooling in microchannels with nanofluids.

TEXT BOOKS:

1. Microscale and Nanoscale Heat Transfer by C. Sobhan and G. Peterson, First edition, CRC Press.
2. Handbook of Nanostructured Materials and Nanotechnology by H.S. Nalwa, I edition, Vol. I and II, American Scientific Publishers.
3. Springer Handbook of Nanotechnology by Bharat Bhushan, 1st edition, Springer-Verlag Publication

REFERENCE BOOKS:

1. Text book of Nano Science and Nano Technology by BS Murthy, P. Shankar, Universities Press.
2. Fluid Mechanics by F. M. White, 5th Edition, McGraw-Hill
3. Heat Transfer by A. Bejan 2nd Edition, John Wiley

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

COMPUTATIONAL METHODS LAB (Lab - I)

Pre-requisite: Heat Transfer and Fluid Mechanics

Course Objective: To apply the principles of Heat Transfer and Fluid Mechanics to solve simple heat transfer and fluid flow problems using commercial CFD software

Course Outcomes: At the end of the course, the student should be able to

- Solve the simple heat transfer and fluid flow problems
- Understand and to appreciate the need for validation of numerical solution

1. Simulation of Couette flow when the upper plate is moving with a velocity of 40 m/s. Take the distance between the plates as 4 cm. Properties of fluid are; v = 0.000217 m^2/s, ρ= 800 kg/m^3. Make simulations for a pressure gradient of 0-30000 $N/m^2/m$ and 20000 $N/m^2/m$ and report the variation of velocity contours for each case.
2. Simulation of a channel flow (Tube flow) for a tube of diameter, 5 cm and take the fluid as water at 30^0C at the entry of the tube of length 0.7 m. A heat flux of 30000 W/m^2 is imposed along the wall. Obtain the contours of velocity and temperature along the length of the tube and also obtain the centre line temperature and velocity of fluid.
3. Simulation of a channel flow (Tube flow) for a tube of diameter, 5 cm and take the fluid as water at 30^0C at the entry of the tube of length 0.7 m. A constant wall temperature of 300^0C is imposed along the wall. Obtain the contours of velocity and temperature along the length of the tube and also obtain the centre line temperature and velocity of fluid.
4. Unsteady simulation of compressible flow of air through 2D a convergent – divergent nozzle, with inlet and outlet of 0.2 m size and both are joined by a throat section where the flow area is reduced by 10% and is of sinusoidal shape. Air enters the nozzle at a pressure of 0.9 atm and leaves at 0.73 atm. Obtain the contours of velocity, pressure and Mach number.
5. Simulation of flow over a circular cylinder of size 5 cm for different Reynold's number values of air and plotting the contours of velocity and vorticity.
6. Simulation of temperature contours for a square plate of size 0.2 m and subjected to different types of boundary conditions
7. Simulation of temperature contours for a pin fin subjected to natural and forced convective conditions
8. Simulation of Natural convection with and without radiation inside an enclosure
9. Simulation of Lid driven cavity problem
10. Structural analysis for beams and trusses

    The experiments are to be conducted using ANSYS – CFX or equivalent software

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

ADVANCED FLUID MECHANICS LAB (Lab - II)

Pre-Requisites: Advanced Fluid Mechanics

Course Objectives:

- To identify the behavior of analytical models introduced in lecture to the actual behavior of real fluid flows.
- To explain the standard measurement techniques of fluid mechanics and their applications.
- To illustrate the students with the components and working principles of the Hydraulic machines- different types of Turbines, Pumps, and other miscellaneous hydraulics machines.
- To analyze the laboratory measurements and to document the results in an appropriate format.

Course Outcomes: Students who successfully complete this course will have demonstrated ability to:

- Describe the measurement techniques of fluid mechanics and its appropriate application.
- Interpret the results obtained in the laboratory for various experiments.
- Compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows and draw correct and sustainable conclusions.
- Write a technical laboratory

List of Experiments:

1. Jet impact on flat and curved surfaces
2. Measurement of drag on a circular cylinder in high Reynolds number flow
3. Energy loss measurements in subcritical and supercritical open channel flow
4. Measurement of fluid viscosity
5. Determination of friction factor as a function of Reynolds number in pipe flow
6. Studying laminar-turbulent transition for flow in a tube
7. Boundary layer flow over a flat plate
8. Pressure distribution around a circular cylinder in high Reynolds number flow
9. Measurements using Forced Vortex Apparatus and Free Vortex Apparatus
10. Measure the losses in piping System
11. Measure Friction loss along a pipe
12. Pulsating flow setup
13. Flow Measuring Apparatus, (H10 Setup)
14. Flow through an Orifice (H4 Setup)
15. Water Flow Channel (H17 Setup)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year I Sem. (THERMAL ENGINEERING)

RESEARCH METHODOLOGY AND IPR

Prerequisite: None

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

Course Outcomes: At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT-I:
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT-II:
Effective literature studies approaches, analysis, Plagiarism, Research ethics

UNIT-III:
Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-IV:
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-V:
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”.

REFERENCES:

1. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
2. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
3. Mayall, “Industrial Design”, McGraw Hill, 1992.
4. Niebel, “Product Design”, McGraw Hill, 1974.
5. Asimov, “Introduction to Design”, Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
7. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ADVANCED I.C. ENGINES (Professional Core - III)

Prerequisites: Thermodynamics, Thermal Engineering I & II

Course objectives: The course is intended to

- Analyze engine cycles and the factors responsible for making the cycle different from the Ideal cycle.
- Apply principles of thermodynamics, fluid mechanics, and heat transfer to influence the engine's performance.
- Understand the delay period and fuel injection system.
- Become aware of the relevance of environmental and social issues on the design process of internal combustion engines

Course Outcomes: At the end of the course, the student will be able to:

- Apply thermodynamic analysis to IC engines and describe combustion phenomena in spark ignition and compression ignition engines.
- Describe the working of major systems used in conventional and modern engines.
- Summarize the methods used to improve engine performance and estimate performance parameters.
- Describe engine emission control techniques and implement viable alternate fuels.

UNIT - I

Introduction – Historical Review – Engine Types – Design and operating Parameters.
Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles – Real Engine cycles - differences and Factors responsible for – Computer Modeling.

UNIT - II

Gas Exchange Processes: Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging.
Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

UNIT - III

Engine Combustion in SI Engines: Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing.
COMBUSTION IN CI ENGINES: Essential Features – Types of Cycle. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

UNIT - IV

Pollutant Formation and Control: Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean, NOx, Catalysts.

UNIT - V

Engine Heat Transfer: Importance of heat transfer, heat transfer and engine energy balance, Convective heat transfer, radiation heat transfer, Engine operating characteristics.
Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen.
Modern Trends in IC Engines: Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

TEXT BOOKS:

1. I.C. Engines by V. Ganesan, TMH
2. I.C. Engines Fundamentals by Heywood, TMH

REFERENCE BOOKS:

1. I.C. Engines by G.K. Pathak & DK Chevan, Standard Publications
2. Dual-Fuel Diesel Engines by Ghazi A. Karim, CRC Press
3. I.C. Engines by RK Rajput, Laxmi Publications
4. Internal Combustion Engines by S.S. Thipse, Jaico
5. Computer Simulation of C.I. Engine Process by V. Ganesan, University Press
6. Fundamentals of IC Engines by HN Gupta, PHI, 2nd edition
7. I.C. Engines by Fergnson, Wiley.
8. The I.C. Engine in theory and Practice Vol. I /Teylor /IT Prof. And Vol. II
9. Computer Simulation of Spark-Ignition Engine Processes by V. Ganesan, Universities Press.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ADVANCED HEAT AND MASS TRANSFER (Professional Core - IV)

Pre-requisite: Thermodynamics
Course Objective: To apply the principles of heat transfer in the design of thermal systems

Course Outcomes: At the end of the course, the student should be able to

- Mathematically model heat and mass transfer and fluid flow problems and to be able to apply different boundary conditions
- Solve the simple heat and mass transfer and fluid flow problems using analytical methods and appreciate the need of numerical methods to solve complicated problems
- Apply semi empirical formulae to determine the heat transfer parameters and use different techniques, viz., experimental, analytical and semi empirical methods to design the thermal systems.

UNIT- I

Introduction to Different Modes of Heat Transfer: Governing Laws and mathematical models - Initial and boundary conditions.
Heat Conduction – Development of Governing equation for 1D, 2D and 3D; steady and transient heat conduction – Solution of 1D steady state heat conduction – Composite Systems.
Systems with heat generation – Variable thermal conductivity – Fins
2D Steady State Heat conduction – Use of conduction shape factors – Use of analytical method for temperature distribution in a slab for simple boundary conditions

UNIT- II

Transient heat conduction: Lumped system analysis-Infinite Bodies - Heisler charts-semi infinite solid -2D transient heat conduction using product solutions.
Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations-derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method-integral analysis – Von Karman Integral Momentum and Energy Equations – Determination of laminar heat transfer coefficient for different velocity and temperature profiles for flow over a flat plate

UNIT- III

External flows: Flow over a flat plate: Application of empirical relations to various geometries for laminar and turbulent flows.
Internal flows: Flow Classification based on hydrodynamic &thermal entry lengths- Fully developed flow: integral analysis for laminar heat transfer coefficient-constant wall temperature and constant heat flux boundary conditions-; use of empirical correlations for determination of heat transfer coefficient and friction factor for different types of internal flow applications.

UNIT- IV

FREE CONVECTION: Approximate analysis on laminar free convective heat transfer-Boussinesque approximation-different geometries-combined free and forced convection.
Boiling and condensation: Boiling curve-correlations-Nusselt's theory of film condensation on a vertical plate-assumptions & correlations of film condensation for different geometries.

UNIT- V

Radiation Heat Transfer: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames.

Mass Transfer: Concepts of mass transfer-diffusion & convective mass transfer analogies-significance of non-dimensional numbers.
Recent Advances in Heat and Mass Transfer Applications.

TEXT BOOKS:

1. Fundamentals of Heat Transfer by Incropera & Dewitt, John Wiley
2. Heat Transfer by Necati Ozisik, TMH
3. Heat Transfer: A Conceptual Approach by P K Sharma and K Rama Krishna

REFERENCE BOOKS:

1. Heat Transfer by Holman J.P, Mc Graw Hill Publication
2. Heat Transfer by Gregory Nellis & Sanford Klein, Cambridge University Press
3. Principals of Heat Transfer by Frank Kreith, Cengage Learning
4. Introduction to Heat Transfer by SK Som, PHI
5. Heat Transfer by Nellis & Klein, Cambridge University Press, 2012.
6. Engineering Heat & Mass Transfer by Sarit K. Das, Dhanpat Rai
7. Heat Transfer by P. K. Nag, TMH

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ADVANCED FINITE ELEMENT AND BOUNDARY ELEMENT METHODS
(Professional Elective - III)

Prerequisite: Strength of Materials, Mathematics, Heat Transfer and Vibrations.
Course Objectives:

- To Introduce the basic concepts of the finite element method, the boundary element method
- To discuss the advantages and limitations of each method
- To Demonstrate the capabilities of each method on a variety of problems

Course outcomes: After completing this course, the student should be able to

- Understand the background of mathematical equations used for development of modeling software modules to develop the various structural related applications
- Identify mathematical model for solution of common engineering problems.
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.

UNIT– I:
One Dimensional Problems: Formulation of Stiffness Matrix for a Bar Element by the Principle of Minimum Potential Energy, Properties of Stiffness Matrix, Characteristics of Shape Functions, Quadratic shape functions.
Analysis of Trusses: Derivation of Stiffness Matrix for Trusses, Stress and strain Calculations, Calculation of reaction forces and displacements.
Analysis of Beams: Derivation of Stiffness matrix for two noded, two degrees of freedom per node beam element, Load Vector, Deflection, Stresses, Shear force and Bending moment, Problems on uniform and stepped beams for different types of loads applied on beams.

UNIT– II:
Finite element – formulation of 2D Problems: Derivation of Element stiffness matrix for two-dimensional CST Element, Derivation of shape functions for CST Element, Elasticity Equations, constitutive matrix formulation, Formulation of Gradient matrix. Two dimensional Isoparametric Elements and Numerical integration.
Finite element – formulation of 3D problems: Derivation of Element stiffness matrix for
Tetrahedron Element, Properties of Shape functions for 3D Tetrahedral Element, Stress-Strain Analysis for 3D Element, Strain Displacement for Relationship Formulation.

UNIT– III:
Steady state heat transfer analysis: One Dimensional Finite Element analysis of fin and composite slabs. **Two-dimensional steady state heat transfer problems:** Derivation of Thermal Stiffness matrix for 2D heat transfer problems-CST, Derivation of thermal force vector for 2D heat transfer problems.
Dynamic Analysis: Formulation of mass matrices for uniform bar and beam Elements using lumped and consistent mass methods, Evaluation of Eigen values and Eigen vectors for a stepped bar and beam Problems.

UNIT– IV:
Plate Bending: Introduction – Plate behavior – C^1 (Kirchhoff) Plate elements – C^0 (Mindlin) Plate elements – Mindlin beam – More devices for C^0 Plate elements – Boundary conditions - Analytical problems.

Nonlinear finite element of solids: Material Nonlinearities, objective rates, nonlinear elasticity, Plasticity, viscoplasticity, viscoelasticity

UNIT–V:

Boundary Element Method: Potential Problems: Introduction, boundary Element Approach-Fundamental solution. Numerical Implementation - Determination of Ci, Final Relation, Three-dimensional analysis, tackling kernel singularity.

Boundary Element Formulation for Electrostatic Problems: Introduction, Basic Relation-Boundary condition, other relations. Discretization and Matrix Formulation – Determination of term $C(p)_m$.

TEXT BOOKS:

1. Finite and Boundary Element Methods in Engineering by O.P. Gupta, Oxford & IBH Publishing Co. Pvt. Ltd
2. The finite element methods in Engineering by S.S. Rao, Elsevier, 4th edition

REFERENCE BOOKS:

1. Finite Element Methods by Alavala, PHI.
2. Introduction to Finite Elements in Engineering by Tirupathi K. Chandrupatla and Ashok D. Belagundu.
3. An Introduction to Finite Element Methods by J. N. Reddy, Mc Graw hill
4. The Finite element method in engineering science by O.C. Zienkowitz, Mc Graw hill.
5. Concepts and Applications of Finite Element Analysis by Robert Cook, Wiley

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

OPTIMIZATION TECHNIQUES AND APPLICATIONS (Professional Elective - III)

Pre-requisites: Operations Research

Course Objectives: The main objectives of the course are:

- Numerical optimization techniques for single variable and multi variable non- linear optimization problems.
- Sensitivity analysis on LPP queuing
- Simulation of annexing problem & inventory problem.
- Geometry cutting plane method & branch bound method for linear IPP.
- Meaning of stochastic programming problem simple problems for finding mean variance of random variables chance constrained algorithm.
- Formulation of GP model and solving it using arithmetic geometric inequality theorem.
- State of art nontraditional optimization technique, namely genetic algorithm simulated annealing & particle swarm optimization.

Course Outcomes: At the end of the course, the student is able to apply appropriate optimization techniques and solve.

- Based on the type of optimization problem like single variable or multivariable,
- Make sensitivity analysis to study effect of changes in parameters of LPP on the optimal solution without reworking.
- Simulate the system to estimate specified performance measures.
- Solve integer programming problem by either geometry cutting plane algorithm or branch band method.
- Apply chance constrained algorithm and solve stochastic linear programme.
- Formulate GP model and solve it.
- Solve given optimization problem by genetic algorithm or simulated annealing or PSO.

UNIT- I:
Single Variable Non-Linear Unconstrained Optimization: Elimination methods: Uni-Model function-its importance, Fibonacci method & Golden section method. Interpolation methods: Quadratic & Cubic interpolation methods.

UNIT- II:
Multi variable non-linear unconstrained optimization: Direct search methods – Univariant method, Pattern search methods – Powell's, Hook -Jeeves, Rosenbrock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves method & variable metric method.

UNIT- III:
Linear Programming – Formulation, Simplex method & Artificial variable optimization techniques: Big M & Two-Phase methods. Sensitivity analysis: Changes in the objective coefficients, constants& coefficients of the constraints. Addition of variables, constraints.
Simulation – Introduction – Types- steps – applications: inventory & queuing – Advantages and disadvantages

UNIT- IV:
Integer Programming- Introduction – formulation – Geometry 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 programming: Chance constrained algorithm.

UNIT- V:

Geometric Programming: Posynomials – Arithmetic - Geometric inequality – unconstrained G.P-constrained G.P (≤ type only)

Non-Traditional Optimization Algorithms: Genetics Algorithm-Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing- Working Principle-Simple Problems. Introduction to Particle Swarm Optimization (PSO) (very brief)

TEXT BOOKS:

1. Optimization theory & Applications by S. S. Rao, New Age International.
2. Optimization for Engineering Design by Kalyanmoy Deb, PHI

REFERENCE BOOKS:

1. Operations Research by S. D. Sharma
2. Operation Research by H. A. Taha, TMH
3. Optimization in operations research by R. L Rardin
4. Optimization Techniques by Benugundu & Chandraputla, Pearson Asia.
5. Optimization Techniques theory and practice by M. C. Joshi & K. M. Moudgalya, Narosa Publications.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

NUMERICAL METHODS FOR ENGINEERS (Professional Elective - III)

Pre-requisites: Mathematics, Differential Equations, Linear Algebra
Course Objectives:

- To solve mathematical and engineering problems by numerical methods
- To improve students programming skills in solving engineering problems by numerical methods

Course Outcomes: Students will understand basics of numerical analysis. Students will be able to find roots of polynomial equations using numerical analysis and solutions of ordinary differential equations including initial value problems, Boundary value problems and Numerical differentiation of data and functions. Students will be able to conduct numerical integration and differentiation and will be able to use numerical methods to solve engineering problems.

UNIT– I
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.

UNIT- II
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 order of discretization - Fourier (von Neumann) stability analysis.

UNIT- III
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.

UNIT- IV
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.

UNIT- V
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.

TEXT BOOKS:
1. Numerical Mathematics and Computing, by Ward Cheney and David Kincaid, International Thomson Publishing Company
2. Applied Numerical Analysis, by Curtis Gerald and Patrick Wheatley, Addison-Wesley

REFERENCE BOOKS:

1. Analysis of Numerical Methods, by E. Isaacson & H. B. Keller, John Wiley & Sons
2. Numerical Solution of Partial Differential Equations: Finite Difference Methods, by G. D. Smith, Oxford University Press, 1985
3. Matrix Computations, by G. H. Golub, Johns Hopkins University Press Numerical Recipes, by W. H. Press et al

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

THERMAL AND NUCLEAR POWER PLANTS (Professional Elective - IV)

Prerequisites: Basic Heat Transfer, Fluid Mechanics

Course Objective: The course is intended to

- Provide in awareness about resources of energies available in India for Power Production by Thermal and Nuclear Processes.
- Understand and know the requirements for a Thermal Power Plant and Nuclear Power Plant, from sources to consumption and economics of power plants.
- Study and learn the processes and cycles followed in Thermal Power Plants and nuclear power plants and components used in the power plants**.**
- Gain the knowledge on steam power plants, steam generators and gas turbine power plants, their analyses on fuel and fluidized bed combustion, ash handling systems.
- Learn the practices followed in Thermal Power Plant and Nuclear Power Plants, to better environmental conditions and the safety measures.
- Gain the knowledge on Power Load calculation, distribution and optimum loading. Etc.
- Know various methods for the Economies of Power Generation and power plant instrumentation.

Course Outcomes: At the end of the course, the student will be able to:

- Describe how fission is accomplished and the basics of how a nuclear reactor produces energy.
- Discuss the thermal cycle and describe heat transfer and fluid flow.
- Identify the major components of a nuclear power plant including generators, turbines, and cooling systems.
- Examine nuclear power plant safety systems and the concepts of redundancy and defense-in-depth.
- Describe the requirements associated with a refuel outage and nuclear fuel reload

UNIT–I:
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.

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

UNIT-III:
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.

UNIT-IV:

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

UNIT-V:

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 by P. K. Nag, TMH
2. Power Plant Engineering by P. C. Sharma, Kotearia, Publications.

REFERENCE BOOKS:

1. Power Plant Engineering by R. K. Rajput, Lakshmi Publications.
2. Power Plant Technology by Wakil, McGraw Hill

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

RENEWABLE ENERGY SOURCES (Program Elective - IV)

Prerequisites: Basics concepts of solar, wind, hydro, biomass, fuel cells and geothermal systems.

Course Objectives: The course is intended to

- Introduce to the technology of renewable sources of energy**.**
- Learn about the solar radiation, its applications and radiation measuring instruments**.**
- Learn about the various types of geothermal resources and its applications**.**
- Study the biomass energy resources, bio-mass systems**.**
- Learn the methods of energy extraction from the wind and oceans**.**
- Learn to the technology of direct energy conversion methods

Course Outcomes: At the end of the course, the student will be able to:

- Identify the renewable energy sources and their utilization.
- Understand the basic concepts of the solar radiation and analyze the solar Thermal systems for their utilization.
- Understand the principle of working of solar cells and their modern.
- Manufacturing techniques.
- Understand the concepts of the ocean thermal energy conversion systems and their applications.
- Outline the methods of energy storage and identify the appropriate methods of energy storage for specific applications.
- Understand the energy conversion from wind energy, geothermal energy, biomass, biogas, fuel cells and hydrogen.

UNIT-I:

Introduction: Overview of the course. Classification of energy resources, energy scenario in the world and India

Basic sun-earth relationships: Definitions. Celestial sphere, altitude-azimuth, declination-hour angle and declination-right ascension coordinate systems for finding the position of the sun, celestial triangle and coordinates of the sun. Greenwich Mean Time, Indian Standard Time, Local Solar Time, sun rise and sun set times & day length. Numerical problems

Solar radiation: Nature of solar radiation, solar radiation spectrum, solar constant, extra-terrestrial radiation on a horizontal surface, attenuation of solar radiation, beam, diffuse and global radiation. Measurement of global, diffuse and beam radiation. Prediction of solar radiation; Angstrom model, Page model, Hottel's model, Liu and Jordan model etc. Insolation on an inclined surface, angle of incidence, Illustrative problems

UNIT-II:

Solar thermal systems: Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant.

Solar concentrating collectors: Classification of solar concentrators, Basic definitions such as concentration ratio, angle of acceptance etc., Tracking of the sun; description of different tracking modes of a solar collectors and the determination of angle of incidence of insolation in different tracking modes. Illustrative problems

Photovoltaic energy conversion: Introduction. Single crystal silicon solar cell, i-v characteristics, effect of insolation and temperature on the performance of silicon cells. Different types of solar cells. Modern technological methods of producing these cells. Indian and world photovoltaic energy scenario.

UNIT-III:

Energy storage: Necessity for energy storage. Classification of methods of energy storage. Thermal energy storage; sensible heat storage, latent heat storage. Reversible chemical reaction storage. Electromagnetic energy storage. Hydrogen energy storage. Chemical battery storage. Pumped hydel energy storage etc.

Wind energy: Origin of winds, nature of winds, wind data measurement, wind turbine types and their construction, wind-diesel hybrid system, environmental aspects, wind energy programme in India and the world.

UNIT-IV:

Ocean energy: Ocean thermal energy; open cycle & closed cycle OTEC plants, environmental impacts, challenges, present status of OTEC systems. Ocean tidal energy; single basin and double basin plants, their relative merits. Ocean wave energy; basics of ocean waves, different wave energy conversion devices, relative merits

Fuel cells: Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cells.

UNIT-V:

Biomass: Introduction, photosynthesis, biofuels, biomass resources, biomass conversion technologies, urban waste to energy conversion, biomass to ethanol conversion, biomass energy scenario in India.

Biogas: Biogas production, constant pressure and constant volume biogas plants, operational parameters of the biogas plant

Geothermal energy: Origin, applications, types of geothermal resources, relative merits

TEXT BOOKS:

1. Non-conventional Energy Resources by B. H. Khan, Tata McGraw Hill, New Delhi, 2012.
2. Energy Technology: Non-Conventional, Renewable and Conventional by S. Rao and B. B. Parulekar, Khanna Publishers, 2010.

REFERENCE BOOKS:

1. Solar Energy-Principles of Thermal Collection and Storage by S. P. Sukhatme and J. K. Nayak, TMH, 2008.
2. Solar Energy Thermal Processes by J. A. Duffie and W. A. Beckman, John Wiley, 2010.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ENERGY CONSERVATION AND MANAGEMENT (Program Elective - IV)

Prerequisites: Environment Studies, Elements of Mechanical Engineering, Thermodynamics

Course Objectives: The course is intended to

- Demonstrate the importance and role of energy management in the functional areas like Manufacturing Industry, Process Industry, Commerce and Government**.**
- To know the different energy resources**.**
- Understand thermodynamic power cycles and the associated processes and fuels**.**
- Understand the economics of energy conversion**.**
- Enable the students to understand the basic energy conversion and management principles and to identify sources of energy loss and target savings**.**
- Enable students in carrying out budgeting and risk analysis**.**
- Analyze the performance of the wind turbine

Course Outcomes: At the end of the course, the student will be able to:

- Explain the fundamentals of energy management and its influence on environment.
- Describe methods of energy production for improved utilization.
- Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
- Analyze the methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.
- Assess energy projects on the basis of economic and financial criteria.

UNIT-I:
Introduction: Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs

UNIT–II:
Energy Audit: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.

UNIT-III:
Economic Analysis: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

UNIT-IV:
Methods of Evaluation of Projects: Payback, Annualized costs, Investor's rate of return, Present worth, Internal rate of return, Pros and cons of the common method of analysis, Replacement analysis.

UNIT-V:
Alternative Energy Sources: Solar Energy: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems.

TEXT BOOKS:

1. Energy Management Hand Book by W.C. Turner (Ed)
2. Energy Management Principles by CB Smith, Pergamon Press

REFERENCE BOOKS:

1. Energy Management by W. R. Murthy and G. Mc. Kay, BS Publication
2. Management by H. Koontz and Cyrill Donnel, McGraw Hill
3. Financial Management by S. C. Kuchhal, Chaitanya Publishing House

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ADVANCED I.C ENGINES LABORATORY (Lab – III)

Prerequisites: Thermodynamics, Thermal Engineering

Course Objective: To apply the laws of Thermodynamics to analyse thermodynamic systems experimentally and perform parametric analysis

Course Outcomes: At the end of the course, the student should be able to

- Apply the laws of Thermodynamics to analyze thermodynamic systems based on measured properties
- Infer from property charts and tables and to apply the data for the evaluation of performance parameters of thermodynamic systems
- Simulation and Performance Evaluation of Thermal and Fluid Flow Systems

List of Experiments:

1. Performance test and analysis of exhaust gases of an I.C. Engine.
2. Heat Balance sheet, Volumetric Efficiency and air fuel ratio estimation of an I.C. Engine.
3. Evaluation of Performance Parameters for Axial Fan and Centrifugal Blower
4. Evaluation of Performance of a Nozzle and Determination of Nozzle Pressure Distribution
5. Determination of Performance Evaluation of Impulse and Reaction Turbines
6. Simulation of Flow Network for Basic Pipe Flow and Interconnection of Pipes
7. Simulation of Flow Network and Performance Evaluation of Rankine Cycle with Reheat and Regeneration
8. Simulation of Flow Network and Performance Evaluation of Brayton Cycle with Inter cooling and Reheat
9. Simulation of Flow and Thermal Networks and Performance Evaluation of a Boiler along with Boiler, Economizer, Super heater and Reheater
10. Steady and Transient Simulation of Compressible Flow Network.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. I Year II Sem. (THERMAL ENGINEERING)

ADVANCED HEAT AND MASS TRANSFER LAB (Lab –IV)

Prerequisites: Heat and Mass Transfer

Course Objective: To apply the principles of Heat Transfer to determine various Heat transfer and Fluid Flow Parameters

Course Outcomes: At the end of the course, the student should be able to

- Determine the thermal property of the solids using energy balance and also using unsteady state analysis
- Determine the heat transfer coefficient of air in free and force convective conditions
- Determine the performance of Recuperative Type heat exchangers
- Determine the drag acting on different surfaces and its effects on pumping power
- Determine performance of thermal equipment like Heat Pipe

List of Experiments:

1. Determination of Thermal Conductivity of a Metal Rod using Searle's Apparatus
2. Determination of thermal Conductivity of a thin disc using Lee's Disc Apparatus
3. Determination of Free Convective Heat Transfer Coefficient of air Using Vertical Rod
4. Determination of Forced Convective Heat Transfer Coefficient of air using Forced Convection Apparatus
5. Determination of Performance of a Heat Pipe
6. Determination of the effectiveness of Parallel and Counter Flow Heat Exchanger
7. Determination of Condensation Heat Transfer Coefficient under Film and Drop wise Condensation Conditions
8. Heat exchanger service module with axillaries Tubular heat exchanger, shell & tube heat exchanger, plate heat exchanger, jacketed vessel with coil and stirrer.
9. Determination of Stefan Boltzmann Constant.
10. Determination of overall heat transfer coefficient using shell & tube heat exchanger.
11. Transient Heat Conduction Experiment.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. II Year I Sem. (THERMAL ENGINEERING)

ADVANCED REFRIGERATION AND AIR CONDITIONING (Professional Core - V)

Prerequisites: Thermodynamics

Course Objectives:

- To apply the principles of thermodynamics to analyze different types of refrigeration and air conditioning systems and to understand the functionality of the major components.

Course Outcomes:

- Differentiate between different types of refrigeration systems with respect to application as well as conventional & unconventional refrigeration systems.
- Thermodynamically analyze refrigeration and air conditioning systems and evaluate performance parameters.
- Apply the principles of psychometrics to design the air conditioning loads for industrial applications.

UNIT– I:

Vapour Compression Refrigeration: Performance of Complete vapor compression system. Actual Vs Ideal cycle - Effect of operating parameters on COP, **Components of Vapor Compression System:** The condensing unit – Evaporators – Expansion valve – Refrigerants – Properties – ODP & GWP - Load balancing of vapor compression Unit.

Compound Compression: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.

UNIT– II:

Production of Low Temperature: Liquefaction system, Liquefaction of gases, Hydrogen and Helium, Cascade System – Applications– Dry ice system.

Vapor absorption system – Simple and modified aqua – ammonia system – Representation on Enthalpy –Concentration diagram.

Lithium – Bromide system Three fluid system – HCOP.

UNIT– III:

Air Refrigeration: Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.

Steam Jet refrigeration system: Representation on T-s and h-s diagrams – limitations and applications.

Unconventional Refrigeration system – Thermo-electric – Vortex tube & Pulse tube – working principles.

UNIT– IV:

Air Conditioning: Psychometric properties and processes – Construction of Psychometric chart. Requirements of Comfort Air –conditioning – Thermodynamics of human body – Effective temperature and Comfort chart – Parameters influencing the Effective Temperature. Summer, winter and year-round air – conditioning systems. Cooling load Estimation: Occupants, equipments, infiltration, duet heat gain fan load, Fresh air load.

UNIT– V:

Air Conditioning Systems: All Fresh air, Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP, RSHF, ESHF and GSHF for different systems.

Components: Humidification and dehumidification equipment – Systems of Air cleaning – Grills and diffusers – Fans and blowers – Measurement and control of Temperature and Humidity.

TEXT BOOKS:

1. Refrigeration & Air Conditioning by C.P. Arora, TMH
2. Refrigeration & Air Conditioning by Arora & Domkundwar, Dhanpat Rai
3. Refrigeration and Air Conditioning by Manohar Prasad
4. Refrigeration and Air Conditioning by Stoecker, Mc Graw Hill

REFERENCE BOOKS:

1. Basic Refrigeration & Air Conditioning by P.N. Ananthanarayanan, McGraw Hill
2. Refrigeration and Air Conditioning by Dr. S.S. Thipse, Jaico
3. Principles of Refrigeration by Dossat, Pearson
4. Refrigeration and Air Conditioning by Jordan& Preister, Prentice Hall
5. Refrigeration and Air Conditioning by Dossat, Mc Graw Hill

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. II Year I Sem. (THERMAL ENGINEERING)

CONVECTIVE HEAT TRANSFER (Program Elective - V)

Prerequisites: Heat Transfer

Course objectives:

- To provide a thorough understanding of applications of convective heat transfer in various thermal systems.
- Students learn analytical and numerical solutions for convective heat transfer problems.

Course Outcome:

- Provide limited design experiences for systems requiring significant consideration to convective heat transfer

UNIT–I:

Introduction to Forced, Free & Combined Convection – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers. **Equations of Convective Heat Transfer:** Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations.

UNIT–II:

External Laminar Forced Convection: Similarity solution for flow over an isothermal plate – integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate. **External Turbulent Flows:** Analogy solutions for boundary layer flows – Integral equation solutions – Effects of dissipation on flow over a flat plate. **Internal Laminar Flows:** Fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields. **Internal Turbulent Flows:** Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.

UNIT– III:

Natural Convection: Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations. Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.

UNIT– IV:

Combined Convection: Governing parameters & equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows - internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.

UNIT–V:

Convective Heat Transfer Through Porous Media: Area weighted velocity – Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers.

TEXT BOOKS:

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David. Naylor /McGraw Hill.
2. Convective Heat & Mass Transfer /Kays & Crawford/TMH.
3. A Heat Transfer Text book by John H. Lienhard V, Phlogiston Press, Third Edition

REFERENCE BOOKS:

1. Convection Heat Transfer / Adrian Bejan/ Hardcover – Import, 17 May 2013.
2. Convective heat transfer, 3rd edition/ Yaman Yener/CRC press-2013.
3. Momentum, Heat, and Mass Transfer by Leo Lue.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. II Year I Sem. (THERMAL ENGINEERING)

ADVANCED MATERIALS FOR THERMAL SYSTEMS (Program Elective- V)

Prerequisites: Materials science, Mechanical Engineering

Course objectives: The course is intended to

- To identify, design and develop new materials and composites for compact thermal energy storage.
- To develop measuring and testing procedures to characterize new storage materials reliably and reproducibly.
- To improve the performance, stability, and cost-effectiveness of new storage materials.
- To develop multi-scale numerical models, describing and predicting the performance of new materials in thermal storage systems.
- To develop and demonstrate novel compact thermal energy storage systems employing the advanced materials.
- To assess the impact of new materials on the performance of thermal energy storage in the different applications considered.
- To disseminate the knowledge and experience acquired in this task

Course Outcomes: At the end of the course, the student will be able to:

- Successfully apply advanced concepts of materials engineering to the analysis, design and development of materials, devices, systems, and processes to meet desired needs of society professionally and ethically.
- Be continuously aware of contemporary issues and research opportunities/challenges in the field of materials engineering as related to energy and sustainability and engage in life-long learning in the field and in the fundamentals of other related disciplines.
- Use advanced materials characterization techniques, skills, and modern scientific and engineering tools.
- Communicate effectively in written and oral form, both, individually and as a member of a multidisciplinary team.

UNIT– I:
Review of MECHANICAL PROPERTIES: FUNDAMENTALS AND TENSILE, HARDNESS, AND IMPACT TESTING: The Tensile Test: Use of the Stress – Strain Diagram, True Stress and True Strain, The Bend Test for Brittle Materials, Hardness of Materials, Strain Rate effects and Impact Behaviour Heat Treatment of Steels and Cast Irons: Designations and Classification of Steels, Simple Heat treatments, Isothermal Heat treatments, Quench and Temper Heat treatments, Surface treatments, Weldability of Steel. FRACTURE MECHANICS, FATIGUE, AND CREEP BEHAVIOUR: Fracture Mechanics, The Importance of Fracture Mechanics, Micro structural Features of Fracture in Metallic Materials, Micro structural Features of Fracture in Ceramics, Glasses, and Composites, Fatigue, Result of the Fatigue test, Application of Fatigue test, Creep, Stress Rupture, and Stress Corrosion, Evaluation of creep Behaviour

UNIT- II:
Nuclear Power Plant and Their Materials: Nuclear reactor, pressurized reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding. Effects of Radiation on Materials Properties: Effects of α, β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials, Effects on crystal structure, grain size etc.

UNIT-III:

Materials in Fuel cells and Solar Cells Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic.

UNIT-IV:

Materials in Thermal Power Generation Super alloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, flyash, etc.

UNIT-V:

Energy storage-Artificial photosynthesis/solar to fuels, CO_2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economy

TEXT BOOKS:

1. Introduction to Nuclear Science by Bryan, J. C., CRC Press.
2. Fundamentals of Radiation Materials Science by G.S. Was, Springer

REFERENCE BOOKS:

1. Nuclear Reactor Materials and Applications by B.M. Ma, Van Nostrand Reinhold Company.
2. Nuclear Reactor Materials by C.O. Smith, Addison-Wesley Publishing Company.
3. Fundamentals Aspects of Nuclear Fuel Elements by D.R. Olander.
4. Structural Materials in Nuclear Power Systems by J. T. A. Roberts, Plenum Press.
5. Handbook of Fuel Cells, Wolf Vielstich by Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
6. Advanced power plant materials, design and technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

ENGLISH FOR RESEARCH PAPER WRITING (Audit Course - I & II)

Prerequisite: None

Course objectives: Students will be able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

UNIT-I:
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II:
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III:
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT-IV:
key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT-V:
skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT-VI:
useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

TEXT BOOKS/ REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

DISASTER MANAGEMENT (Audit Course - I & II)

Prerequisite: None

Course Objectives: Students will be able to

- learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- critically understand the strengths and weaknesses of disaster management approaches,
- planning and programming in different countries, particularly their home country or the countries they work in

UNIT-I:
Introduction:
Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

UNIT-II:
Repercussions Of Disasters And Hazards:
Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT-III:
Disaster Prone Areas In India:
Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

UNIT-IV:
Disaster Preparedness And Management:
Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

UNIT-V:
Risk Assessment Disaster Risk:
Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co- Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

UNIT-VI:
Disaster Mitigation:
Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

TEXT BOOKS/ REFERENCES:

1. R. Nishith, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “’New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.),” Disaster Mitigation Experiences And Reflections”, Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies” ,Deep &Deep Publication Pvt. Ltd., New Delhi.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

SANSKRIT FOR TECHNICAL KNOWLEDGE (Audit Course - I & II)

Prerequisite: None

Course Objectives:

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learning of Sanskrit to improve brain functioning
- Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
- The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Course Outcomes: Students will be able to

- Understanding basic Sanskrit language
- Ancient Sanskrit literature about science & technology can be understood
- Being a logical language will help to develop logic in students

UNIT-I:
Alphabets in Sanskrit,

UNIT-II:
Past/Present/Future Tense, Simple Sentences

UNIT-III:
Order, Introduction of roots,

UNIT-IV:
Technical information about Sanskrit Literature

UNIT-V:
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TEXT BOOKS/ REFERENCES:

1. “Abhyaspustakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

VALUE EDUCATION (Audit Course - I & II)

Prerequisite: None

Course Objectives: Students will be able to

- Understand value of education and self- development
- Imbibe good values in students
- Let the should know about the importance of character

Course outcomes: Students will be able to

- Knowledge of self-development
- Learn the importance of Human values
- Developing the overall personality

UNIT-I:
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

UNIT-II:
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT-III:
Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness.

UNIT-IV:
Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT-V:
Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation, Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively

TEXT BOOKS/ REFERENCES:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

CONSTITUTION OF INDIA (Audit Course - I & II)

Prerequisite: None

Course Objectives: Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcomes: Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

UNIT-I:
History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working)

UNIT-II:
Philosophy of the Indian Constitution: Preamble**,** Salient Features

UNIT-III:
Contours of Constitutional Rights & Duties: Fundamental Rights Right to Equality**,** Right to Freedom**,** Right against Exploitation**,** Right to Freedom of Religion**,** Cultural and Educational Rights**,** Right to Constitutional Remedies, Directive Principles of State Policy**,** Fundamental Duties.

UNIT-IV:
Organs of Governance: Parliament**,** Composition**,** Qualifications and Disqualifications**,** Powers and Functions**,** Executive**,** President**,** Governor**,** Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualification, Powers and Functions

UNIT-V:
Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.Pachayati raj: Introduction, PRI: Zila Pachayat.Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments),Village level: Role of Elected and Appointed officials, Importance of grass root democracy

UNIT-VI:

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

TEXT BOOKS/ REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

PEDAGOGY STUDIES (Audit Course - I & II)

Prerequisite: None

Course Objectives: Students will be able to:

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

Course Outcomes: Students will be able to understand:

- What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

UNIT-I:

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and Searching.

UNIT-II:

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

UNIT-III:

Evidence on the effectiveness of pedagogical practices, Methodology for the indepth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the scho curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT-IV:

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes

UNIT-V:

Research gaps and future directions: Research design**,** Contexts**,** Pedagogy**,** Teacher education**,** Curriculum and assessment**,** Dissemination and research impact.

TEXT BOOKS/ REFERENCES:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

STRESS MANAGEMENT BY YOGA (Audit Course - I & II)

Prerequisite: None

Course Objectives:

- To achieve overall health of body and mind
- To overcome stress

Course Outcomes: Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

UNIT-I:
Definitions of Eight parts of yog. (Ashtanga)

UNIT-II:
Yam and Niyam.

UNIT-III:
Do`s and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT-IV:
Asan and Pranayam

UNIT-V:
i) Various yog poses and their benefits for mind & body
ii) Regularization of breathing techniques and its effects-Types of pranayam

TEXT BOOKS/ REFERENCES:

1. 'Yogic Asanas for Group Tarining-Part-I": Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. TECH. (THERMAL ENGINEERING)

PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS
(Audit Course - I & II)

Prerequisite: None

Course Objectives:

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

Course Outcomes: Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students

UNIT-I:

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)

UNIT-II:

Neetisatakam-Holistic development of personality

- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

UNIT-III:

Approach to day to day work and duties.

- Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48,
- Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
- Chapter 18-Verses 45, 46, 48.

UNIT-IV:

Statements of basic knowledge.

- Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18
- Personality of Role model. Shrimad Bhagwad Geeta:

UNIT-V:

- Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

TEXT BOOKS/ REFERENCES:

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.