NOTIFICATION

No. 193 /2023 Dated : 23 /11/2023

Subject : Implementation of new syllabus of Semester I to IV of the Course M.E. Mechanical Engineering (Thermal Engineering) as per CBCS Pattern from the Session 2023-2024 onwards.

It is notified for general information of all concerned that the authorities of the University have accepted to implement the new syllabus of Semester I to IV of the Course **M.E. Mechanical Engineering (Thermal Engineering)** as per Choice Based Credit System Pattern from the Session 2023-2024 onwards as mentioned below:

Sd/-
(Dr.T.R.Deshmukh)
Registrar

SYLLABUS PRESCRIBED FOR TWO YEARS P. G. DEGREE COURSE IN

M.E. Mechanical (THERMAL ENGINEERING) (CBCS)

SEMESTER - I

1MTE1: ADVANCED FLUID DYNAMICS

Course Objectives:

1. To familiarize the students about the fluid dynamics and its applications to model the real life engineering problems
2. To Apply the basic applied-mathematical tools that support fluid dynamics

Course Outcomes:-

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

1. Ascertain basic concepts of the fluid mechanics and apply the concepts in the analysis of fluid flow problems
2. Explain the governing equations of fluid flow to obtain the exact solutions to N-S equation
3. Analyze the fluid flow problems using potential flow theory.
4. Interpret & apply boundary layer theory for various fluid flow problems.
5. Analyze & solve the equations of turbulent flow and its models.
6. Describe the concept of compressibility of fluid flow & governing equations.

SECTION – A

UNIT-I: Governing Equations:

(a) **Review of Fluid Mechanics: -** Definition and properties of Fluids, Fluid as continuum, Continuum model, Flow kinematics:-Langragian and Eulerian description, Substantial or Total derivatives, Basic flow-analysis techniques**,** Flow Patterns: Streamlines, Streaklines, and Pathlines.

(b) **Integral Relations for a Control Volume**: Reynolds transport theorem, Conservation of mass, Linear momentum equation, Energy equation, Frictionless flow, Bernoulli equation

(c) **Differential Relations for a Fluid Particle:** Acceleration field of a fluid, Differential equation of mass conservation, Differential Equation of linear momentum, Differential equation of Energy, Boundary Conditions for the basic equations, Velocity Potential, Stream Function, Vorticity.

UNIT II: Navier-Stokes Equations:

(a) Generalized form of NSE, Special forms: Euler equations, Bernoulli equation.

(b) **Exact solutions** of Navier Stokes equations**:** fully developed flow in channel, pipe, flow between concentric rotating cylinders, Couette flow, Hagen-Poiseuille flow; flow over a flat pate,
cylinders and spherical bodies; Stokes First problem (unsteady flow), Creeping flow past a sphere, cylinder.

UNIT-III: Potential Flows

Elementary Plane-Flow Solutions: Circulation, Superposition of Plane-Flow Solutions: Irrotational vortex, Vortex Lines, vortex tubes, Vortex flow, Doublet, Flow past a circular cylinder, Magnus effect; Role of viscosity in rotational and irrotational flows.

SECTION – B

UNIT IV: Boundary layer theory:
Boundary layer theory for laminar and Turbulent flow, Blasius solution for flat plate, approximate methods, boundary layer separation and control, Effect of roughness. Effect of pressure gradient, Separation, Secondary flow.

UNIT V: Turbulent flow:
Introduction to Turbulent Flow, characteristics of turbulence, laminar-turbulent transition, Correlation functions, Mean and fluctuations, Governing equations, Turbulent boundary layer for internal and external flows, Boundary conditions, shear stress models, Prandtl's mixing length, Velocity profile over a flat plate and in pipes, Taylor's theory of turbulence dispersion

Unit VI: Compressible flow:
Review of one dimensional compressible flow, speed of sound, variable cross-section flow, converging-diverging nozzle, Fanno and Rayleigh curve, normal shock relation, past slender bodies, compressible boundary layer, Prandtl Mayor's Equation.

Text Books:

1. Cengel, Y.A. and J.M. Cimbala, Fluid Mechanics, McGraw-Hill, Boston, MA
2. Mechanics of Fluids, Shames, McGraw-Hill.
3. Advanced Engineering Fluid Mechanics, Muralidhar, K and Biswas, G., Alpha Science International Ltd.,3rd Edition, 2018.
4. Viscous Fluid Flow, White, F. M., Tata McGraw Hill Book Company, 2021, 4th Edition.
5. Introduction to Fluid Mechanics, Fox, R.W., Pritchard, P. J. and McDonald, A. T., Wiley, 2018, 8th Edition.
6. Foundations of Fluid Mechanics, Yuan, S. W., Prentice Hall of India, 2000

Reference Books:

1. Fluid Mechanics, Kundu, P. K., and Ira M. Cohen, 4th ed., Academic Press.
2. The Dynamics and Thermodynamics of Compressible Flow, Shappiro, Ronald Press.
3. Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, Yahya, S. M., New Age International Publishers, 2018, 6th Edition.
4. Modern Compressible Flow –with Historical Perspective, Anderson, J. D. Jr., TMH, 2020, 4th edition.
5. Boundary Layer Theory, Schlichting, H and Gersten, K, 9th Edition, Springer, 2018.

1MTE2: ADVANCED THERMODYNAMICS

Course objectives:
Objectives of this course are:

1. To provide the sufficient knowledge of thermodynamics to apply in real engineering problems
2. To familiarize the students about the thermodynamic relations and process and their use to analysis the given thermal application
3. To understand the gas equations for properties generation

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

1. Estimate the properties of pure substance and thermodynamic properties of real gases
2. Apply various laws of thermodynamics to suit the engineering applications.
3. To analyze Mechanisms of Entropy Generation
4. Describe and calculate thermodynamic properties of single-phase and multi-phase systems
5. Apply energy balances to reacting systems for both closed and open systems.
6. Apply exergy analysis to various thermodynamic systems.

SECTION –A

Unit I: Introduction and Overview:
Introductory Concepts and Preliminaries; Properties of Pure Substances; Energy and the First Law of Thermodynamics, Energy Transfer by Heat, Work, and Mass; Second Law of thermodynamics, Entropy: A Measure of Disorder, Exergy – A Measure of Work Potential

Unit II: The Two Laws Combined: Review on some consequences of first Law, Limitations of first Law, Thermodynamic Tempera-ture Scale, Clausius Clapeyron Equation, Stefan' s Law, Helmholtz and Gibbs Functions, Availability in Steady Flow, Irreversibility and Effectiveness, Combined First and Second Laws, Isothermal and Adiabatic Compressibility; Joule Kelvin**–III** Coefficient, Maxwell Equation, Vander Wall's Gas Equation;

Unit III: The Destruction of Energy:
Lost Available Work, Mechanisms of Entropy Generation or Energy Destruction, Entropy Generation Minimization.

SECTION –B

Unit IV: Multi-Phase Systems:
General considerations, Dalton &Amagat Model, Mixture of gases and vapors. Changes in Molal Properties upon Mixing, Gibbs Entropy Equation and Gibbs -Duhem Equation.

Unit V: Chemically Reactive Systems:
Thermodynamics of reactive Systems and Criterion of Equilibrium, Phase rule. Combustion Process, Enthalpy of formation; First Law Analysis of Reacting Systems; Second Law analysis of Reacting Systems, Equilibrium Constant and its temperature Dependence.

Unit VI: Exergy Analysis of Thermal Systems:
Exergy, Physical and Chemical Exergy; Applications of Exergy Analysis, Exergy analysis of Vapor and Gas Power Cycles, Guideline for improving Thermodynamic Effectiveness; Energy analysis of Simple Power Plant (Steam Plant)

Text Books:
1. Advanced Engineering Thermodynamics, Adrian Bejan, Wiley Inter science Publication, Second Edition, ISBN 0-471-14880-6.
2. Fundamentals of Engineering Thermodynamics, Michael Moran & Howard Shapiro, Wiley & Sons, Sixth Edition, ISBN 978-0-471-787358
3. Fundamental of thermodynamics, Richard E. Sonntag, Gordon J. Van Wylen, Claus Borgnakke, John Wiley & Sons publication.

Reference Books:
1. Fundamentals of Classical Thermodynamics, Richard Sonntag, Claus Borgnakke, John Wiley & Sons, Seventh Edition, ISBN: 978- 0-470-04192-5.
2. Thermodynamics: An Engineering Approach, Yunus A. Cengel& Michael A. Boles, Sixth Edition, ISBN-13 9780073305370.

1MTE3: Programme Elective I: (I) REFRIGERATION & CRYOGENICS

Course Objectives:
1. To impart knowledge about principles of producing low temperatures by using multi-pressure systems and cascade systems.
2. To educate about various system components and accessories of refrigeration systems.

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

1. Analyze the performance of vapor compression refrigeration systems
2. Compare the performance of multi-stage vapor compression systems
3. Design and analyze vapor absorption system
4. Understand the design and working of non-conventional refrigeration systems
5. Select the various components of vapor compression refrigeration systems and their controls
6. Design refrigeration systems that can produce low temperatures required in many industrial applications.

SECTION – A

Unit I: Refrigeration Cycles – Analysis:
Vapor Compression Refrigeration Cycle analysis- conditions for high COP-deviations from ideal vapor compression cycle.
Refrigerants: Classification of Refrigerants, Refrigerant properties, Eco-friendly Refrigerants, alternatives to HCFCS, mixed refrigerants, Secondary Refrigerants.

Unit II: Multi-pressure Systems:
Multi stage compression with water intercooler, liquid sub-cooler, flash chamber, flash intercoolers and multiple expansion valves, multi evaporator systems, cascade refrigeration system
Unit III: Vapor Absorption Systems:
Vapor Absorption Systems-Aqua Ammonia & Li-Br Systems, Temperature concentration and enthalpy concentration diagrams, enthalpy balance for various components of aqua ammonia systems, Vapour absorption system- Electrolux refrigerator.

SECTION – B

Unit IV: Non - Conventional Refrigeration Systems:
Steam jet refrigeration system, Performance analysis of steam jet refrigeration system, thermo-electric refrigeration system, vortex tube Refrigeration, adiabatic demagnetization, vapor adsorption refrigeration system

Unit V: Refrigeration Systems Components:
Compressor- Types, performance, Types of Evaporators and Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load, cyclingcontrols, other components such as Accumulators, Receivers, Oil Separators, Strainers, Driers,Check Valves, Solenoid Valves Defrost Controllers, etc.

Unit VI: Cryogenics:
Introduction and applications of Cryogenics, Properties of cryogenic fluids, Gas Liquefaction and refrigeration systems: LindeHampson system, Precooled LindeHampson system, Linde dual pressure system, Claude system, Pulse Tube cryocooler, Cryogenic Insulations- Multilayer insulation (MLI)

Text Books:

1. Arora, C.P., “Refrigeration and Air Conditioning”, 4th edition, McGraw Hill, 2021.
2. Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001.
3. Refrigeration & Air Conditioning , Manohar Prasad New Age, 2018 .
4. Barron R., “Cryogenic Systems”, Plenum Press, 2001.
5. Refrigeration & Air Conditioning Domkunduwar, and Arora, Dhanpatrai & Sons, 2015.

Reference Books:

1. Refrigeration& Air, Conditioning, Stoecker W.F. Jones, J.W., McGraw Hill, 2014.
2. Walker G., “Cryocoolers”, Springer, 2014.

1MTE3: Programme Elective I (ii) GAS TURBINES & JET PROPULSION

Course Objectives:
Objectives of this course are-

1. To Understand the concept of gas turbines
2. To familiarize the students about the Jet propulsion and its whole thermodynamic analysis
3. To understand the applications of Jet propulsion

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

1. Describe the General Concepts related to Turbo machinery
2. Analyze performance of centrifugal compressor
3. Analyze the Axial Flow Turbines
4. Articulate the Performance calculations for Combined Cycle.
5. Illustrate Thermodynamics Of Aircraft Jet Engines Theory of Jet Propulsion
6. Interpret Aero-Thermodynamics of Jet Propulsion Subsystems Subsonic inlets

SECTION - A

General Concepts related to Turbo machinery: Classification; Euler’s Equation for Turbo machinery; Velocity triangle; Cascade analysis & nomenclature. Shaft Power & Aircraft Propulsion Cycles

Centrifugal Compressors: Work done and pressure rise; Slip; Compressibility effects; Compressor characteris-tics. Axial Flow Compressors: Stage pressure rise; Blockage in compressor annulus; Degree of reaction; 3- D flow; Stage performance; h-s diagram & efficiency; off design performance; Performance characteristics; Design process. Combustion System.

Axial Flow Turbines: Stage performance; Degree of reaction; h-s diagram & efficiency; Vortex theory; Overall turbine performance; Performance characteristics; Blade cooling; Design process. Prediction of performance of simple gas turbines; Off Design performance; Gas turbine blade materials; matching procedure

Combined cycles: Differences between Single and combined Cycles, characteristics of combined cycles, Performance calculations for Combined Cycle.

SECTION - B

Thermodynamics Of Aircraft Jet Engines Theory of Jet Propulsion - Thrust and efficiency - Ram Jet - Turbojet and Turbofan engines - Turboprop and Turbo-shaft Engines - Thrust augmentations - Typical engine performance - Engine - Aircraft matching.

Aero-Thermodynamics Of Jet Propulsion Subsystems Subsonic inlets - Supersonic inlets - Gas turbine combustors - After burners and Ramjet Combustors -Supersonic Combustion - Exhaust Nozzles

Text Books:

1. Philip G. Hill and Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Second Edition.
2. Bonney E.A. Zucrow N.J. Principles of Guided Missile Design, Van Nostranc Co., 1985.
3. S.M. Yahya, Gas Dynamics and Jet Propulsion.

Reference Books:

1. Addition - Wesley Publishing Company, New York, 1992.
2. Zucrow N.J. Principles of Jet Propulsion and Gas Turbines, John Wiley and Sons Inc, New York, 1970.
3. Zucrow N.J. Aircraft and Missile Propulsion, Vol. I and Vol. II, John Wiley and Sons Inc, New York, 1975.

1MTE3: Programme Elective I: (iii) FUELS AND COMBUSTION

Course Objectives:

1. To impart knowledge about the importance of alternate fuels.
2. To explain the concepts of combustion
3. To familiarize the students about engine alteration to use alternative fuels

Course Outcomes:

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

1. Identify the fuel thermo-chemistry and fuel quality effects on emissions.
2. Calculate and estimate performance and emission characteristics of alternative fuels
3. Apply the knowledge of combustion to deal with real life problems.
4. Describe combustion characteristics and how these can be measured.
5. Explain basic concepts about combustion processes for efficient designing of burners for different types of fuels and combustion chambers.
6. Analyze environmental effects of combustion of various fuels, suggest modification in their usage.

SECTION – A

Introduction: General, Conventional Energy Sources, Solar Energy, Nuclear Power, Energy from Biomass, Wind Power, Tidal Power, Geothermal Energy, Energy Survey of India, Rocket Fuels.

Solid, Liquid & Gaseous Fuels:

General, Family of Coal, Origin of Coal, Gasification of Coal, Analysis and Properties of Coal, Action of Heat on Coal, Classification of Coal, Oxidation of Coal, Hydrogenation of Coal, Efficient use of Solid Fuels.Manufactured Fuels, Agro Fuels, Solid Fuel Handling, Properties Related to Combustion, Handling Storage

Theory of Combustion Process:

Origin and Classification of Petroleum, Refining and Other Conversion Processes, Composition of Petroleum with respect to Combustion, Property & Testing of Petroleum Products, Various Petroleum Products, Nature of Indian Crudes & Petroleum Refining in India, Liquid Fuels from Other Sources, Storage and Handling of Liquid Fuels, Liquid Fuels Combustion Equipment. Types of Gaseous Fuels, Natural Gases, Methane from Coal Mines, Manufactured Gases, Producer Gas, Water Gas, Carbureted Water Gas, Blast Furnace Gas Fuels, Through Non-Thermal Route - Biogas, Refinery Gas, LPG, Cleaning and Purification of Gaseous Fuels.

SECTION – B

Stoichiometry: Stoichiometry and Thermodynamics, Combustion Stoichiometry General, Rapid Methods of Combustion Stoichiometry, Combustion Thermodynamics, Problem, Combustion Problems with Chemical Reactions Burners Stoichiometry Relations, Theoretical Air Required for Complete Combustion, Calculation of Minimum Amount of Air Required for a Fuel of known Composition,

Calculation of Dry Flue Gases if Fuel Composition is Known, Calculation of the Composition of Fuel & Excess Air Supplied,from Exhaust Gas Analysis, Dew Point of Products, Flue Gas Analysis (O 2, CO 2, CO, NO x, SO x).

Burner Design: Ignition, Concept of Ignition, Auto Ignition, Ignition Temperature. Flame Propagation, Various Methods of Flame Stabilization, Incorporation in Burner Design, Basic Features and Types of Solid, Liquid and Gaseous Fuel Burner, Design Consideration of Different Types of Coal - Oil and
Gas Burners, Recuperative & Regenerative Burners

Text Books:

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990.
2. Bhatt ,vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mc-graw Hill, 1984

Reference Books:

1. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 1988
2. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966

1MTE4: Programme Elective-II: (i) ADVANCED INTERNAL COMBUSTION ENGINES

Course Objectives:

1. To impart knowledge about the S.I & C.I engines
2. To introduce the fundamental concepts relevant to pollutant emissions.
3. To enable the students to understand the factors that cause the effects of emissions.

Course Outcomes:

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

1. Analyze and evaluate the performance parameters of spark ignition engines, such as power output, torque, efficiency, and specific fuel consumption.
2. Knowledge of engine operation and control systems like fuel injection timing, electronic control units (ECUs), sensors, and actuators.
3. Learn about various techniques and instruments used to measure and monitor pollutant concentrations in various types I C Engine.
4. Investigate the various sectors where alternative fuels are being used such as transportation (e.g., electric vehicles, biofuel-powered vehicles), industrial processes, and power generation.
5. Investigate ongoing research and development efforts in the field of lean burn engines.

SECTION - A

Spark Ignition Engines: Spark ignition engine mixture requirements – Fuel – Injection systems – Monopoint, Multipoint injection, Direct injection – Stages of combustion – Normal and abnormal combustion – Factors affecting knock – Combustion chambers.

Compression Ignition Engines: States of combustion in C.I. Engine – Direct and indirect injection systems – Combustion chambers – Fuel spray behaviour – Spray structure, Spray penetration and evaporation – Air motion – Introduction to Turbo charging.

SECTION - B

Pollutant Formation And Control: Pollutant – Sources – Formation of carbon monoxide, Un burnt hydrocarbon, NOx, Smoke and Particulate matter – Methods of controlling Emissions – Catalytic converters and Particulate Traps – Methods of measurements and Introduction to emission norms and Driving cycles.

Alternative Fuels: Alcohol, Hydrogen, Natural Gas and Liquefied Petroleum Gas Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.

Recent Trends: Lean Burn Engines: Stratified charge Engines – homogeneous charge compression ignition engines – Plasma Ignition – Measurement techniques – Laser Doppler, Anemometry.

Text Books:

1. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications, 2002.
2. R.B.Mathur and R.P. Sharma, Internal combustion Engines.
3. V. Ganesan, Internal Combustion Engines, II Edition, Tata McGrawHill, 2002.

Reference Books:

1. Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc.
2. John B. Heywood, Internal Combustion Engine Fundamentals first edition
3. Willard W. Pulkrabek, engineering fundamentals of the Internal Combustion Engine second edition

1MTE4: Programme Elective-II: (ii) DESIGN AND ANALYSIS OF TURBOMACHINES

Course Objectives:

- 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.

Course Outcomes:

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

1. Explain the working principles of turbo-machines and apply them to various types of turbo-machines
2. Design centrifugal compressors
3. Design axial flow compressors
4. Design and analyze performance of Radial flow Turbines
5. Design and analyze performance of Axial flow Turbines
6. Analyze the performance of Jet Engines.

SECTION – A

Unit I: Introduction to Turbo machines:
Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations -area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbo-machines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic.

Unit II: Centrifugal Compressors:
Centrifugal Compressors: Principle of operation, Work done and pressure rise, Components of centrifugal compressor, Stage pressure, Stage efficiency, Degree of reaction, Dimensionless parameters, Slip factor, Causes of slip, Velocity triangles, Euler work, Design of impeller, Design of diffuser.

UNIT III: Axial Flow Compressors: Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses.

SECTION – B

Unit IV: Radial Flow Turbines: Radial Turbines - Elements of radial turbine stages – Enthalpy-Entropy diagram – stage velocity triangles – stage losses – performance characteristics – outward flow radial stages.

Unit V: Axial Flow Turbines Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twinspool arrangements – performance. Matching of components. Blade Cooling.

Unit VI: Gas Turbine and Jet Engine Cycles
Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scarmjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

Text Books:

1. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, DhanpatRai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997.

Reference Books:

1. Centrifugal compressors: A basic guide by M.P. Boyce, Penn Well Books.
2. Axial Flow Compressors: A strategy for aerodynamic design and Analysis by R. Aungier, ASME Press.
3. Turbine Compressors and Fans by S.M.Yahya, Tata McGraw-Hill

1MTE4: Programme Elective-II (iii) POWER PLANT ENGINEERING

Course Objectives:

1. To analyze different types of steam cycles and estimate efficiencies in a steam power plant
2. To describe basic working principles of steam power plant, gas turbine and non-conventional power plants.
3. To provide Knowledge of the various types of conventional and non-conventional power plants.

Course Outcomes:

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

1. Apply the principles of thermodynamics to analyze the performance of power plants
2. Design and develop power plant components for optimum performance
3. Analyze the performance of combined cycle based plants
4. Understand the working of Nuclear power plant and its components
5. Compare the performance of various types of non-conventional power plants.
6. Evaluate economics of power plants

SECTION – A

Unit I: Introduction to power plants: Energy resources and their availability, types of power plants –merits and demerits, selection of the plants, review of basic thermodynamic cycles used in power plants. Steam Power Plants: Flow sheet and working of modern-thermal power plants, site selection, plant efficiency

Unit II: Steam generators and their accessories: High pressure Boilers, Modern generators, once through and fluidized bed boilers design. Design of accessories, Steam generator control, Draught system,fuel and ash handling systems.

Condensers: Types, Effect of various parameters on condenser performance, Design of condensers, Cooling towers and cooling ponds.

Unit III: Combined Cycles: Gas turbine power plants, Arrangements of combined plants (steam & gas turbine power plants), parameters affecting thermodynamic efficiency of combined cycles, Integrated gasification combined cycle, PFBC based combined cycle, re-powering of thermal power plant.

SECTION – B

Unit IV: Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, Nuclear cross-section, different components of nuclear power station, PWR, BWR, CANDU, liquid metal cooled, gas cooled, fast breeder, nuclear waste disposal.

Unit V: Non-conventional energy generation: Geothermal power plant, Tidal and wave power plant, solar power plant, wind power generation, direct to electricity method - Magneto-hydrodynamic (MHO) power generation

Hydro-Electric Power Plants: Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, comparison with other types of power plants.

Unit-VI: Power Plant Economics: load curves, different terms and definitions, base load and peak load plants, energy storage, cost of electrical energy, tariffs, methods of electrical energy, performance & operating characteristics of power plants - incremental rate theory, input-output curves, efficiency, heat rate, economic load sharing.

Learning Resources:

Text Books:

1. Power Plant Engineering, P. K. Nag, McGraw Hill Education; 2017,4th Edition.
2. M.M.EI Wakil: Power Plant Technology, Tata McGraw-Hill
3. Domkundawar, “Power Plant Engineering”, DhanpatRai& Sons,1980

Reference Book: Power Plant engineering, P. C. Sharma, S.K. Kataria & Sons, New Delhi, 2010.

1MTE5: RESEARCH METHODOLOGY and IPR

Course Objectives:

1. To familiarize students with the different aspects of research.
2. To provide an idea of good scientific writing and proper presentation skills.
3. To provide an understanding of philosophical questions behind scientific research.
4. To provide a brief background on the historical legacy of science.
5. To provide an insight of nature of Intellectual Property and new developments in IPR.

Course Outcomes:

1. Understand research problem formulation
2. Analyze research related information and follow research ethics
3. Understand that today’s world is controlled by computer, information technology but Tomorrow’s world will be ruled by ideas, concepts and creativity
4. Understand that IPR would take such important place in growth of individuals and nation , it is needless to emphasize the need of information about Intellectual Property Right to be promoted among students in general and Engineering
5. Understand the nature of Intellectual Property and IPR in International Scenario

6. 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.

SECTION-A

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

SECTION-B

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.

Unit VI: 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.

Books Recommended:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”Model Curriculum of Engineering & Technology PG Courses [Volume -II]
3. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step by Step Guide for beginners”
4. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd., 2007.
5. Mayall , “Industrial Design”, McGraw Hill, 1992.
6. Niebel , “Product Design”, McGraw Hill, 1974.
7. Asimov , “Introduction to Design”, Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008
10. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press, 2004.
11. Ramappa T, “Intellectual Property Rights Under WTO”, S. Chand, 2008.
12. Kothari C. R, “Research Methodology - Methods and Techniques”, New Age Int. publishers, New Delhi, 2004.

1MTE6: FLUID DYNAMICS - Lab.

Course Objectives:

The course should enable the students to:

1. Gain knowledge on working of centrifugal pumps, positive displacement pumps, hydraulic turbines centrifugal blowers and steam turbines.
2. Compare performance of various machines at different operating points.
3. Knowledge of various flow meters and the concept of fluid mechanics

List of Experiments: (Any Six)

1. Performance test on centrifugal pumps
2. Performance test on reciprocating pumps
3. Performance test on Pelton wheel turbine
4. Performance test on Francis turbine
5. Study Impact of jet on Vanes
6. Axial flow fan: Constant speed performance test on an axial flow fan.
7. Centrifugal blower: Constant speed performance test on a centrifugal blower.

1MTE7: THERMAL ENGINEERING Lab. – I

Course Objective:
To conduct experiments on various Thermal Engineering devices to study the performance and its applications.

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

1. Evaluate the properties of fuels and oils.
2. Analyze the performance and emissions of I C Engines
3. Analyze the performance of steam power plant components
4. Analyze the performance of refrigeration system
5. Evaluate the performance of components of steam power plant

List of Experiments: (Any Six)

1. Determination of the calorific value of the given sample of fuel.
2. To conduct a constant speed performance test on the steam turbine.
3. To determine the performance characteristics of the nozzles.
4. Performance study in a cooling tower
5. Performance study on Boiler.
6. Performance test on vapor compression refrigeration system
7. Performance test on vapor absorption system
8. Performance test on Ice plant
9. Performance test on Cascade Refrigeration system
10. Performance test of 4-stroke Petrol Engine.
11. Performance test of 4-stroke Diesel Engine.
12. Heat Balance Preparation for 4-stroke Diesel Engine.
13. Heat Balance Preparation for four-stroke Petrol Engine
14. Determination of friction power of multi-cylinder petrol engine using Morse Test Method.
15. Performance test on variable compression ratio petrol and diesel engines
16. Performance test on Spark Ignition engine and Compression Ignition using the alternate fuels.
17. Measurement of smoke density and composition of the engine exhaust of a CI Engine during a constant speed performance test.
18. Emission measurement in Spark Ignition Engine
19. Properties of fuel oils, biomass, biogas.
20. Study on Fuel Cell Systems.

1MTE8: AUDIT COURSE I and II: (i) ENGLISH FOR RESEARCH PAPER WRITING

Course Objectives: Students will be able to:
1. Demonstrate writing meaningful sentences and coherent paragraphs
2. Show conciseness, clarity and avoid redundancy in writing
3. Summarize, evaluate literature, and write methodology, results and conclusion
4. Describe how to develop title, write abstract and introduction
5. Apply correct style of referencing and use punctuation appropriately

Course Outcomes:
1. Explain planning and preparation required for research communication
2. Use appropriate word order and write short sentences, writing coherent paragraphs and sentences
3. Demonstrate conciseness, clarity and avoid redundancy
4. Write abstract, introduction, summarize, evaluate literature, methodology, discussions, results and conclusion
5. Use correct punctuation, correct style(s) of in-text citation and bibliography and avoid plagiarism.

SECTION-A

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.

SECTION-B

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

Books Recommended:

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'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

1MTE8: AUDIT COURSE I and II (ii) DISASTER MANAGEMENT

Course Objectives:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. 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

Course Outcomes:

1. Knowledge of disaster and its types.
2. Knowledge of Repercussions of Disasters And Hazards.
3. Study of Seismic Zones and Disaster Prone Areas In India.
4. Study of Disaster Preparedness and Management.
5. Understanding Disaster Risk Situation, Risk Assessment and Disaster Mitigation in India.

SECTION-A

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

SECTION-B

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

Books Recommended:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.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.

1MTE8: AUDIT COURSE I and II (iii) SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives: Students will be able:

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

Course Outcomes:
1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science and technology can be understood
3. Being a logical language will help to develop logic in students

SECTION-A

Unit I: Alphabets in Sanskrit,
Unit I: Past/Present/Future Tense,
Unit III: Simple Sentences

SECTION-B

Unit IV: Concepts in Mathematics, Order, Introduction of roots,
Unit V: Technical information about Sanskrit Literature
Unit VI: Technical concepts of Engineering-Electrical, Mechanical, Architecture

Books Recommended:
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.

1MTE8: AUDIT COURSE 1 and 2: (iv) VALUE EDUCATION

Course Objectives: Students will be able to:
1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Course Outcomes:
1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

SECTION-A

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 judgments
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. Avoid fault Thinking, Free from anger, Dignity of labour.

SECTION-B

Unit IV: 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.
Unit VI: All religions and same message. Mind your Mind, Self-control. Honesty, studying effectively.

Book Recommended:
1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford Uni Press, New Delhi

1MTE8: AUDIT COURSE 1 and 2: (v) CONSTITUTION OF INDIA

Course Objectives:
1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. 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.
3. 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:

1. Knowledge of History and Philosophy of the Indian Constitution.
2. Understanding the Contours of Constitutional Rights & Duties.
3. Study of Organs of Governance.
4. Understanding the Local Administration.
5. Study of Election Commission.

SECTION-A

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 and 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.

SECTION-B

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, Qualifications, 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.

Books Recommended:

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.

1MTE8: AUDIT COURSE 1 and 2: (vi) PEDAGOGY STUDIES

Course Objectives: Students will be able to:

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

Course Outcomes:

1. Knowledge of Theories of learning and Conceptual framework.
2. Understanding the Pedagogical practices.
3. Theory of change when pedagogical practices are done.
4. Understanding the Professional development and Barriers to learning.
5. Study of Research gaps and future directions.

SECTION-A

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 in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

SECTION-B

Unit IV: 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 V: 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 VI: Research gaps and future directions, Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

Books Recommended:

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.

1MTE8: AUDIT COURSE 1 and 2: (vii) STRESS MANAGEMENT BY YOGA

Course Objectives: Students will be able to:
1. To achieve overall health of body and mind
2. To overcome stress

Course Outcomes:
1. Knowledge of Eight parts of yog(Ashtanga).
2. Understanding the Do`s and Don't's in life.
3. Knowledge of Yam and Niyam, Asan and Pranayam.
5. Regularization of breathing techniques and its effects.
6. Develop healthy mind in a healthy body thus improving social health and efficiency

SECTION-A

Unit I: Definitions of Eight parts of yog. (Ashtanga)
Unit II: Do`s and Don't's in life.
Yam. Ahinsa, satya, astheya, bramhacharya and aparigraha
Unit III: Niyam. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

SECTION-B

Unit IV: Asan and Pranayam
Unit V: Various yog poses and their benefits for mind & body
Unit VI: Regularization of breathing techniques and its effects-Types of pranayam

Books Recommended:

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

1MTE8: AUDIT COURSE 1 and 2: (viii) PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Course Objectives: Students will be able to:
1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students.

Course Outcomes:
1. Knowledge of Holistic development of personality (Neetisatakam)
2. Approach to day to day work and duties.
3. Understanding the personality of role model will lead the nation and mankind to peace and prosperity
4. Study of Personality Development through life enlightenment skills and achieve the highest goal in life.

SECTION-A

Unit I: Neetisatakam - Holistic development of personality
Verses- 19,20,21,22 (wisdom)
Verses- 29,31,32 (pride & heroism)

Unit II: Neetisatakam -Holistic development of personality
Verses- 26,28,63,65 (virtue)
Verses- 52,53,59 (dont's)
Verses- 71,73,75,78 (do's)

Unit III: Approach to day to day work and duties.
ShrimadBhagwadGeeta: Chapter 2-Verses 41, 47,48,

SECTION-B

Unit IV: Approach to day to day work and duties.
Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35,
Chapter 18-Verses 45, 46, 48.

Unit V: Statements of basic knowledge.
ShrimadBhagwadGeeta: Chapter2-Verses 56, 62, 68
Chapter 12 -Verses 13, 14, 15, 16,17, 18

Unit VI: Personality of Role model. Shrimad Bhagwad Geeta:
Chapter2-Verses 17, Chapter 3-Verses 36,37,42,
Chapter 4-Verses 18, 38,39
Chapter18 – Verses 37,38,63

Books Recommended:
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.

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SEMESTER II

2MTE1: COMPUTATIONAL METHODS IN THERMAL ENGINEERING

Course Objectives:
The course is expected to enable the students

- To inculcate subject knowledge of numerical methods applied to thermal engineering applications
- To select a specific numerical method to solve practical problems.

Course Outcomes:

At the end of this Course the students are expected to be able to:

1. Solve linear and nonlinear algebraic equations and systems of nonlinear equations using numerical techniques
2. Use regression and interpolation methods for curve fitting.
3. Select and apply numerical schemes for differentiating and integrating complicated functions.
4. Apply computational schemes for solving systems of ordinary differential equations.
5. Solve PDEs by numerical methods
6. Design and develop computer programs for the various numerical methods to solve engineering problems.

SECTION - A

Unit I: Introduction to Numerical Analysis: Objectives, Mathematical Modeling, Programming Concepts, Computational Accuracy, Precision, Truncation Errors, Taylor Series Curve fitting and Regression, Interpolation, Fourier series concepts.

Unit II: Roots of equations: Bisection, False position, Fixed Point Iteration, Newton-Raphson, Secant methods, Roots of polynomials Linear Algebraic Equations, Gauss Elimination
Unit III: Non-linear Systems of Equations, Gauss-Jordan, LU Decomposition and Matrix Inversion, Gauss-Seidel.

SECTION - B

Unit IV: Numerical Integration: Trapezoidal and Simpson's Rules, Gaussian Quadrature. Numerical Differentiation and finite-difference approximations.

Unit V: Numerical solutions of Ordinary Differential Equations: Euler's and Runge-Kutta Methods, Boundary-Value, Eigen value and Eigen vector problems.

Unit VI :Numerical solutions of Partial Differential Equations: Elliptic Equations, Laplace Equation and Boundary Conditions, Control Volume Approach, Parabolic Equations, Explicit and Implicit Methods, Crank-Nicolson, Introduction to Finite Element Methods.

Note: Computer Programs for the above methods are to be practiced using any high level language.

Texts / References:

1. Steven C. Chapra and Raymond P. Canale, Numerical Method for Engineers, 6th Edition, McGraw-Hill, 2010.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, 5th Edition, PHI Learning, 2012
3. S. P. Venkateshan, Computational Methods in Engineering, 1st Edition, Academic Press, 2013
4. S.K. Gupta, Numerical Methods for Engineers, New Age International, 2009
5. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge, 2007
6. K. Atkinson and W. Han, Elementary Numerical Analysis, 3rd Edition, Wiley-India, 2004.
7. J. D. Hoffman and Steven Frankel, Numerical Methods for Engineers and Scientists, 2nd Edition, McGraw-Hill, 2001
8. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980

2MTE2: ADVANCED HEAT TRANSFER

Course Objectives:

1. To impart knowledge of 2D conduction heat transfer.
2. To understand radiative heat transfer with & without participating media.
3. To formulate and analyze combined heat transfer problems.

Course Outcomes:

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

1. Analyze steady state heat conduction problems of real life thermal systems
2. Use of analytical tools to investigate heat transport phenomena.
3. Calculate Heat transfer coefficients for laminar and turbulent flows
4. Solve the forced convection heat transfer problems for internal and external flows
5. Analyze the problems of phase change heat transfer like boiling and condensation
6. Analyze radiation heat transfer problems of various thermal systems.

SECTION – A

Unit I: Steady state conduction:

Heat Transfer Fundamentals, Steady and Transient Heat Transfer, General Heat Conduction Equation, Multidimensional steady state conduction: Fins of non-uniform cross section, Two dimensional heat conduction analytical, graphical analysis, Conduction shape factor,formulation in terms of resistances of elements, Accuracy considerations

Unit II: Unsteady state heat conduction:

Lumped system analysis, Applicability of Heisler charts, Semi-infinite slab and cylinder, use ofshape factors in conduction, 2D transient heat conduction, Thermal resistance and capacity formulation.

Unit III: Principle of Fluid flow and Convective heat transfer:

Concept of velocity and thermal boundary layers, Laminar and Turbulent flow,Navier-stokes equations and convection equation, Boundary layer approximations and special conditions. Boundary layer similarity, derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method, integral analysis.

SECTION – B

Unit IV: Forced Convection:

(a) External flows: Flow over a flat plate: integral method for laminar heat transfer coefficient fordifferent velocity and temperature profiles. Application of empirical relations to variousgeometries for laminar and turbulent flows.

(b) Internal flows: Fully developed flow: integral analysis for laminar heat transfer coefficient typesof flow-constant wall temperature and constant heat flux boundary conditionshydrodynamic &thermal entry lengths; use of empirical correlations.

Unit V: (a) Natural Convection:
(a) Physical Mechanism, Equation of motion and Grash of Number, Natural Convection over flat and inclined surfaces, Natural convection from finned surfaces and PCBs, Natural Convection inside enclosures (Rectangular, Cylinder and Sphere), Combined Natural and Forced Convection, Correlation for convection and boiling condensation

(b) Boiling and condensation: Boiling curve, correlations, Nusselts theory of film condensation on a vertical plate, assumptions and correlations of film condensation for different geometries.

Unit V: Thermal Radiation:
Introduction to basic fundamentals, Radiation shape factor**,** Radiation heat transfer in two surface enclosures, Radiation shields, Heat exchange between non-black bodies using network approach, gasradiation, radiation network for an absorbing and transmitting medium,Effect of radiation on temperature measurement, Radiation heat transfer coefficient.

Note: **Heat transfer data book will be permitted in Exam hall**.

Text Books:
1. J.P. Holman, Heat Transfer, Tata McGraw Hill Publication, 9th ed.2002.
2. S.P. Sukhatme, Heat Transfer, Tata McGraw Hill Publication, 1994.
3. Yunus A. Cengal, *Heat and Mass Transfer* – A practical Approach, 3rd edition, Tata McGraw -Hill, 2007.
4. Incropera F.P. and DeWitt. D.P., *Fundamentals of Heat & Mass Transfer*, John Wiley & Sons, 2002.
5. Ghoshdastidar P.S.*, Heat Transfer*, Oxford University Press, 2004
6. Heat Transfer by P.K. Nag, Tata McGraw Hill Publication, 2005.

Reference Books:
1. Heat and Mass Transfer Data Book Book by C P Kothandaraman, SSubramanyam, New Age International,1994
2. Heat Transfer data book Convective heat and mass transfer by Kaysand Crawford, Tata
3. Convective Heat transfer, A Bejan, John Wiley and sons.

2MTE3: Programme Elective-III: (i) AIR-CONDITIONING SYSTEM DESIGN

Course Objectives:
1. To provide the sufficient knowledge of concept, applications, importance of air conditioning
2. To familiarize the students about the air conditioning system design and its applications in real life situations
3. To learn the duct design and load calculation.

Course Outcomes:
At the end of the course, student will be able to:
1. Describe the fundamental of psychometrics and different air condition system
2. Identify the requirements and parameters for human comfort
3. Estimate heating and cooling loads for air condition system
4. Analyze various air conditioning systems and select appropriate components
5. Design Air distribution, duct design for suitable Air-conditioning system.
6. Apply knowledge to solve many real life problems of air conditioning system

SECTION – A

Unit I: Psychrometry: Properties of Air Water Mixture, Ideal Adiabatic saturation process, Relationship between Wet-Bulb Temperature and Thermodynamic Wet-Bulb Temperature, Relations between psychrometric properties, Psychrometric chart, Use of psychrometric charts and moist air tables, Psychometric Air Conditioning Processes, Air washer, By pass Factor, ADP, Applied Psychrometry – RSHF, GSHF and ESHF. Numerical on Applied Psychrometry.

Unit II: Thermal Comfort: Thermal comfort, Parameters governing human comfort, Various comfort indices, Heat transfer from human body by sensible and latent heat transfer. Metabolic heat generation, steady state and unsteady state model for heat transfer, effect of clothing and definition of effective temperatures. ASHRAE comfort chart, Infiltration and ventilation, Indoor Air Quality (IAQ), Sources of indoor air pollution, methods of control of IAQ, Fresh air requirements for IAQ.

Unit III: Heating and Cooling load calculations: Differences between winter and summer load calculations, Inside and Outside design conditions, Various sources of the internal and external heat gains, heat losses, Solar radiation, Solar radiation through glass, Heat transfer through building structure, Methods of heat load calculations, Numerical on summer and winter load calculations.

SECTION –B

Unit IV: Air Conditioning Systems:
Selection criteria for air conditioning systems, Classification of air conditioning systems, Central and unitary air conditioning, Special features of residential, Commercial and industrial air conditioning system, Year round air conditioning, All air systems, All water systems, Air-water systems, Direct Refrigerant, Unitary systems, Chilled water systems and their types,Working principle, advantages, disadvantages and applications of all air systems, eg. Single duct, constant volume, and single/multiple zone system, single duct, dual duct, constant & variable air volume (VAV) systems, outdoor air control in all air systems.

Unit V: Duct Design & Room Air Distribution:
Important requirements of an air conditioning duct, General rules for duct design, Classification of duct systems, Pressure drop calculation for various types of duct, Duct design methods–velocity deduction, Equal friction and static regain method, Performance of duct systems, System balancing and optimization, Duct design procedure–dynamic loss coefficient method, Equitable length method, Air distribution terminology, Air distribution system in rooms, Supply and return grills.

Unit VI: Air Conditioning System Design:
Design Air Conditioning system for Hospital / Restaurant / Commercial building / Supermarkets and select suitable Air Conditioning Equipment for the above design (Compressor, Condenser, Expansion device, Evaporator, Fan, Cooling coil, Pumps, etc); HVAC Equipment, Packaged and Split HVAC Equipment, Heat pump Design and selection, Equipment Selection, Auxiliaries.
Noise and Vibration Control In Air Conditioning Hall.

Text Books:

1. Refrigeration and air conditioning, AhmadulAmeen, Prentice Hall of India, New Delhi, 2006
2. Refrigeration and air conditioning, C P Arora, Tata McGraw-Hill, 2nd ed, 2003
3. Air Conditioning Principles and Systems, E G Pita, Prentice Hall of India, 4th edition, 2005.
4. Handbook of Air conditioning and Refrigeration, Shan K. Wang, McGraw Hill

Reference Books:

1. The ASHRAE Handbooks with CDs, 2005-2008
2. Refrigeration and Air Conditioning Technology, Tomczyk, J. A., Whitman, W. C., Johnson, W. M., Pub: Delmar S. Africa, 4th edition, 2000.
3. Air conditioning Applications and Design, Jones W. P., Edward Arnold Publishers Ltd.
4. Handbook of Heating, Ventilation and Air Conditioning- Jan F.Kredier- CRC

2MTE3: Programme Elective-III: (ii) DESIGN AND OPTIMIZATION OF THERMAL SYSTEMS

Course Objectives:

1. To impart knowledge of overall design requirement and methodology of a thermal system.
2. To model of a thermal system.
3. To learn tools and techniques of performance analysis of a thermal system.
4. To learn techniques of economic analysis of thermal system.
5. To introduce students about the methods of optimization of a thermal systems

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

1. Identify and examine a design problem associated to a thermal system,
2. Make use of system simulation, curve fitting and mathematical modelling for fluid flow and heat transfer applications
3. Perform economic analysis of a thermal system
4. Use optimization procedures to design thermal systems
5. Apply search methods for constrained and unconstrained optimization problems
6. Apply different techniques of optimization to design thermal systems.

SECTION – A

Unit I: Introduction to System Design:

Basic Considerations in design, Morphology of design with a flow chart, formulation of Thermal systems; Concept of workable design, practical example on workable system and optimal design. Computer-aided design of thermal systems, Material selection, Properties and characteristics for thermal systems.

Unit II: Modeling of Thermal systems:

Mathematical modeling of thermal systems: Basic features of modeling, System and types of Model, characteristic of models, Curve fitting, exact fit, best fit.

Numerical modelling and simulation: Solution procedure, Numerical model for a system, System simulation, Methods for numerical simulation. Acceptable design of a thermal system, Design of system from different applications.

Unit III: Economic Considerations:

Introduction, calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, rate of return, application to thermal systems.

SECTION – B

Unit IV: Introduction to Optimization:

Introduction: Need of optimization, Basic concepts- Objective function, constraints, mathematical formulation for optimization.

Unit V: Methods of Optimization:

Optimization-Problem formulation for optimization: Optimization methods, practical aspects in optimal design. Optimization of constrained and unconstrained problems, search methods, method of steepest ascent/ steepest descent, conjugate gradient method, geometric programming, dynamic programming, linear programming,: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming.

Unit VI: Design and optimization of thermal systems:

Thermodynamic optimization, entropy generation minimization, application to internal and external flows, design of heat exchangers and other energy-equipment optimization.

Learning Resources:

Text Books:

1. C. Balaji, Essentials of Thermal System Design and Optimization, Ane Books, New Delhi in India and CRC Press in the rest of the world, 2011.
2. Jaluria, Yogesh. Design and optimization of thermal systems. CRC press, 2007.
3. Rao, Singiresu S., and S. S. Rao. Engineering optimization: theory and practice. John Wiley & Sons, 2009.
4. K. Deb; Optimization for Engineering Design; Prentice Hall of India, 2005.

Reference Books:

1. Elements of thermal fluid system design, L.C. Burmeister, Prentice Hall, 1998.
2. Design of thermal systems, W.F. Stoecker, McGraw Hill, 1989.
3. Dieter, G.E.,Engineering Design: A Materials and Processing Approach, McGraw-Hill, 2008.
4. Collier, Courtland A., and William Burl Ledbetter. Engineering economic and cost analysis. Harpercollins College Division, 1988.

2MTE3: Programme Elective III: (iii) COMPUTATIONAL FLUID DYNAMICS

Course Objectives:

1. To learn the methodology of numerical analysis of heat and fluid flow problems.
2. To develop an understanding for the major theories, approaches and methodologies used in CFD
3. To build up the skills in the actual implementation of CFD methods (e.g. boundary conditions, turbulence modelling etc.) in using commercial CFD codes
4. To gain experience in the application of CFD analysis to real engineering designs.

Course Outcomes:

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

1. Derive the governing equations and understand the behaviour of the equations
2. Derive algebraic equations using finite volume methods for various fluid flow and heat transfer problems.
3. Analyze the error and uncertainty in numerical models used for various algorithms.
4. Build skills in the actual implementation of CFD methods (e.g., boundary conditions, different numerical schemes etc.)
5. Apply their knowledge to solve a system of linear algebraic equation using standard direct and iterative technique,
6. Identify applications of finitevolume and finite element methods to solveNavier-Stokes equations.

SECTION – A

Review of Governing Equations: Governing Equations of Fluid flow andheat transfer, review of numerical methods.

Discretization: Introduction to finite differences, difference equations,explicit and implicit approaches: definition and contrasts, errors andanalysis of stability.

Classification of Partial Differential Equations: Explicit and Implicitmethods, solution of select model equations; Laplace heat and waveequation, laminar boundary layer solution

SECTION – B

CFD Techniques: The lax -wendroff technique, Mac Cormack's technique, Relaxation technique and its use with low speed inviscid flows, aspects of numerical dissipation and dispersion; artificial viscosity, Alternating Direction Implicit (ADI) technique, pressure correction technique with application to incompressible viscous flow.

Initial And Boundary Value Problems: Free falling of a spherical body, two dimensional motions of a body through a fluid radial flow.

Text Books:

1. Computational Fluid Flow and Heat Transfer, Muralidhar, K. and Sundararajan, T., Narosa Pub., 2004.
2. Computational Fluid Dynamics: The Basics with Applications, Anderson, J. D., Jr. McGraw Hill, 2002.
3. Computational Fluid Dynamics: An Introduction for Engineers, Abbot, M. B. and Basco, D. R., John Wiley & Sons, 2006.
4. Computational Fluid Dynamics: Principles and Applications, Blazek, J., Elsevier Science, 2001.

2MTE4: Programme Elective –IV: (i) DESIGN OF HEAT EXCHANGERS

Course Objectives:

- To understand design principles of various types of heat exchangers
- To analyze the sizing and rating of the heat exchangers for various applications.

Course Outcomes:

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

1. Identify different types of heat exchangers and understand the primary design methodologies
2. Design and analyze the double pipe, and shell and tube heat exchanger
3. Analyze the thermal performance of tube finned and plate finned heat exchanger
4. Evaluate the thermal performance of Casketed and Spiral plate heat exchanger
5. Calculate the pressure drop in the tubular and extended surface heat exchanger
6. Analyze the performance of condenser and cooling towers

SECTION – A

Unit I: Fundamentals of Heat Exchangers:

Classification, shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers Constructional details, Two and Multi-fluid heat exchangers, Temperature distribution; extended surfaces – LMTD and effectiveness method.

Unit-II: Design of Tubular Heat Exchanger: Heat transfer coefficient, double pipe heat exchanger design, Shell & tube type heat exchangers, nomenclature, J-factors, conventional design methods, bell, Delaware method.

Unit III: Design of Extended Surface Heat Exchanger: Enhancement of heat transfer compact heat exchanger, Compact heat exchangers, J-factors, Design method Extended surface heat exchanger, Rating problem of tube finned heat exchanger, Rating problem of plate finned heat exchanger, Pressure drop calculations and tutorials, Sizing problem.

SECTION – B

Unit IV: Design of Plate Heat exchangers: Introduction, Types of the plate heat exchanger– merits and demerits, thermal design of Gasketed plate heat exchanger, thermal design of spiral plate heat exchanger–performance influencing parameters – limitations

Unit V: Heat Exchanger Pressure Drop Analysis: Importance of pressure drop, Major contributions to the heat exchanger pressure drop, Tubular heat exchanger pressure drop, Extended surface heat exchanger pressure drop, Plate heat exchanger pressure drop

Unit VI: Condensers and Cooling Towers: Design of surface and evaporative condensers – cooling tower – performance characteristics. Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

Text Books:

1. Compact Heat Exchangers, Kays, W. M. and London, A. L., McGraw – Hill, New York, 2nd Edition, 1998.
2. Fundamentals of Heat Exchanger Design, Shah, R. K. and Sekulic, D. P., John Wiley and Sons, New Jersey, 2003.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and Dewitt, D. P., 7th Edition, John Wiley and Sons, New York, 2013.

Reference Books:

1. Arthur P. Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. Hewitt G.F., Shires G.L. and Bott T.R., Process Heat Transfer, CRC Press, 1994.
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981.
4. SadikKakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002.
5. Sekulic D.P., Fundamentals of Heat Exchanger Design, John Wiley, 2003.
6. TaborekT.,Hewitt.G.F. andAfgan N., Heat Exchangers, Theory and Practice, McGraw-Hill Book Co. 1980.
7. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
8. Cooling Towers / J.D.Gurney and I.A. Cotter/ Maclaren

2MTE4: Programme Elective IV: (ii) EXPERIMENTAL METHODS IN THERMAL ENGINEERING

Course Objectives:

1. To introduce the theory and experimentation in thermal engineering - Problem solving approaches, and types of engineering experiments,
2. To enhance the knowledge of various measuring instruments, techniques and importance of error and uncertainty analysis.
3. To give the exposure to measurement of pressure, flow velocity, measurement of temperature, optical methods of measurement.

Course Outcomes:

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

1. Identify the suitable instrument for measuring parameters as per performance characteristics
2. Analyze experimental data by using different statistical techniques and estimate error
3. Distinguish different methods of temperature measurements and thermal radiation
4. Classify various pressure measurement instruments and their comparison
5. Explain different flow measurement methods and flow visualization techniques
6. Apply knowledge of modern engineering experimentation, including calibration, data acquisition, and data analysis.

SECTION – A

Basics of Measurements: Introduction, general measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Presentation of experimental data, Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Dynamic response – zeroth, first and second order measurement systems, Design of Experiments, Data Acquisition Systems, Integration of industrial instrumentation systems and monitoring.

Unit I: Measuring instruments:

Basics of Measurements: Fundamental elements of a measuring instrument, Calibration, System response, Importance of measurement and experimentation, Selection of measuring system.

Characteristics of instruments: Elements of Measuring Instruments Performance characteristics - Static & Dynamic characteristics, Response of general form of instrument, Random and transient input, Instrument loading under static and dynamic condition, Transducer and sensor used for thermal systems

Unit II: Design of Experiments

Analysis of Experimental Data: Analysis of experimental data, Causes and type of experimental errors, data reduction techniques, statistical analysis of experimental data, Statistical distributions, probability distributions and curve fitting, Regression analysis, Co-relations

Uncertainty Analysis: computation of overall uncertainty; Precision Vs Accuracy, Errors in measurement, Sampling

Unit III: Temperature and Heat flux measurement: Overview of thermometry, Thermoelectric temperature measurement, Hg-in-glass thermometer, RTD (Resistance Temperature Detector), thermistor, thermocouple, thermopile, liquid-crystal thermography, optical pyrometer. Themo well, Issues in Heat flux measurements. Thermos profile of heat exchanger. Non-contact type temperature Measurements

Thermal radiation measurements: Detection of thermal radiation, Radiation Thermometry, Measurement of emissivity, Reflectivity and transmissivity measurements, Solar radiation measurements.

SECTION – B

Unit IV: Pressure measurement:

Different pressure measurement instruments and their comparison, Types of Sensors used in Pressure Measurement, Manometers, bourdon tube pressure gauge, diaphragm gauge, bellow gauge, McLeod gauge, Pirani gauge and ionization gauge. Transient response of pressure transducers. Applications of Pressure measurements.

Unit V: Flow measurement and Visualization techniques:

Flow measurements: Introduction to Flow Measurement, Positive displacement flow meters, Flow obstruction methods, hot-wire anemometers, Magnetic flow meters, LDA (Laser Doppler Anemometry), flow measurements using coriolis effect; Applications of flow measurements.

Flow visualization techniques: Shadowgraph, Schlieren and interferometer.

Unit VI: Data Acquisition System (DAS) and Signal analysis:

General Data Acquisition System, Signal conditioning, storage, Data transmission, - A/D & D/A conversion - Data storage and Display.

Learning Resources:

Text Books:

1. Measurement systems by Ernest O Doebelin, Dhanesh N. Manik, Tata McGraw Hill publications, 2019, 7th Edition,.

2. Mechanical Measurements by Thomas G Beckwith, Roy D. Marangoni and John H. LienhardVPearson publications, 2020, 6th Edition.

3. Experimental Methods for Engineers by J P Holman, Tata McGraw Hill publications, 2017, 7th Edition.

Reference Books:

1. An Introduction to Error Analysis, by John R. Taylor, University Science Books, 1997, 2nd Edition

2. Mechanical Measurements by S P Venkateshan, Ane Books Pvt. Ltd., 2015, 2nd Edition.

2MTE4: Programme Elective IV (iii) ENERGY CONSERVATION AND WASTE MANAGEMENT

Course Objectives:

- To learn the present energy scenario and the need for energy conservation.
- To learn the methods for energy auditing.
- To study the various measures for energy conservation for various thermal utilities.
- To elaborate on the technologies available for generating energy from waste.

Course Outcomes:

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

1. Understand various energy sources and consumption patterns.
2. Apply various energy conservation techniques to estimate energy-saving potential through energy audit
3. Identify and assess the energy conservation opportunities in different thermal systems
4. Understand solid waste management techniques
5. Analyze various methods of energy generation from waste
6. Evaluate the performance of heat recovery system for industrial applications

SECTION – A

Unit- I: Global and National Energy Scenario:

Energy consumption in various sectors, Energy resources like Coal, Oil, and Natural Gas –their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, India's installed energy capacity, per capita energy consumption. Common areas of inefficiency in energy use, principles of energy conservation, Roles of energy auditors, Roles of an energy manager, Energy policy of industry, Energy Conservation Act and its amendments.

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: Energy Conservation in Thermal Utilities:
Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation, maintenance of steam traps, and energy-saving opportunities in steam systems. Energy Efficiency in Furnaces and Refractories.

SECTION – B

Unit- IV: Waste Management:
Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization- Disposal of Hazardous Waste.

Unit- V: Waste to Energy Conversion:
Municipal Solid Waste Management; Waste Generation and characterization, Waste Processing Techniques; Source Reduction, Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery, waste plastic, RDF/Sewage utilization, Govt. Policies on MSW and RDF, Introduction to Microbial Fuel Cell

Unit- VI: Waste Heat Recovery:
Classification, Advantages and applications, Selection criteria for waste heat recovery technologies, waste heat recovery devices: recuperators, regenerators, economizers, plate heat exchangers, thermic fluid heaters, Waste heat boilers-design aspects; fluidized bed heat exchangers, heat pipe exchangers, heat pumps; Saving potential.

Text Books:
1. Energy Management audit & Conservation, De, B. K., Vrinda Publication, 2010, 2nd Edition.
2. Energy Management, Murphy, W. R., Elsevier, 2007, 1st Edition.

Reference Books:
1. Lee SS EDS, Seagate Subrata, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
2. Advance Energy Systems, Nikolai V. Khartchenko, Taylor and Francis Publishing, 2013, 2nd Edition.
3. Powerplant Technology, M.M.El-Wakil, Tata McGraw Hill, 20103, Indian Edition
4. Energy Management Hand book, Doty, S. and Truner, W. C., Fairmont Press, 2009, 7th edition.

2MTE5: THERMAL SYSTEMS SIMULATION – Lab.

Course Outcomes:
After completion of this course, students will be able to:
1. Solve ordinary differential equations (ODEs), and partial differential equations (PDEs) on a computer
2. Develop numerical solutions for linear and non-linear algebraic equations using computer programs
3. Derive numerical solutions to initial value problems and boundary value problems
4. Solve fluid flow and heat transfer problems using a CFD solver.
5. Develop computer code to solve both steady and transient heat conduction problems
6. Derive numerical solutions to various convection-diffusion problems using multiple schemes such as central difference scheme, upwind scheme, and hybrid differencing scheme

List of Experiments: (Any six)

(Coding using any computer language)

1. Solving basic mathematical problems such as curve fitting, numerical differentiation andintegration and numerical solution of differential equation using any computer language.
2. Finding roots using the Bisection method
3. Discovering roots using the Newton-Rapson method
4. Solving ODE using the Rung-Kutta method
5. FDM code to solve PDE: elliptic equation
6. FDM code to solve PDE: parabolic equation
7. FDM code to solve PDE: hyperbolic equation
8. Heat conduction with and without source term
9. Pin-fin problem

10. Convection-diffusion problem based on central difference scheme
11. Convection-diffusion problem based on the upwind scheme
12. Convection-diffusion problem based on the hybrid differencing scheme
13. Explicit method based transient heat conduction problem
14. Implicit scheme based transient heat conduction problem
15. Solving governing equation of fluid flow and heat transfer using numerical methods (By using any computer language.

(Using Ansys-Fluent, CFX, Phoenix or any Open source software)

16. Heat transfer simulation through a solid medium (Steady-state/Transient + various boundary conditions + with and without source term)
17. Fluid flow simulation through the channel (Laminar/ Turbulent)
18. Flow and heat transfer simulation through a porous medium
19. Non-isothermal flow simulation through channel/enclosure/over bodies (Laminar + Turbulent)
20. Multiphase modelling & simulation
21. Flow & Heat transfer simulation for various engineering applications.

2MTE6: THERMAL ENGINEERING Lab. – II

Course Objectives:

1. To provide practical training for conducting experiments related to advanced heat transfer.
2. To apply scientific and engineering principles to analyze and design thermo fluid aspects of systems
3. To investigate heat and mass transport phenomenon

Course Outcomes:

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

1. Evaluate the heat transfer characteristics in conduction, convection and radiation
2. Interpret results of investigations related to heat transfer, fluid flow and thermal design
3. Evaluate the performance of heat exchangers experimentally

List of Experiments: (Any six)

1. Determination of thermal conductivity of insulating powder
2. Determination of the Stefan-Boltzmann constant and comparison with the theoretical value
3. Heat transfer through composite wall: Determination of theoretical end experimental values of equivalent thermal resistance of a composite slab
4. To determine the LMTD and effectiveness of the double pipe heat exchanger in parallel and counter flow modes.
5. Critical radius of insulation
6. Lumped heat transfer analysis
7. Heat Pipe Demonstrator: Demonstration of near isothermal characteristic exhibited by a heat pipe in comparison to stainless steel and copper pipes
8. Pulsating heat pipe experiments
9. Two-phase flow experiments
10. Free convection experiment: Determination of experimental and empirical values of convection heat transfer coefficient from a Vertical Heated Cylinder losing heat to quiescent air
11. Forced convection experiment: Determination of theoretical, experimental and empirical values of convection heat transfer coefficient for internal forced convection through a circular pipe
12. Pin-Fin Apparatus: Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment
13. Emissivity measurement
14. Heat exchanger analysis – NTU method.
15. Condensation heat transfer analysis.

2MTE7: SEMINAR

Course Objectives:

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

Course Outcomes:

1. Review, prepare and present on recent technological developments
2. Organize a detailed literature survey and build a document with respect to technical publications.
3. Make use of new and recent technology (e.g. Latex) for to prepare technical report
4. Establish motivation for any topic of interest and develop a thought process for technical presentation.
5. Analysis and comprehension of proof-of-concept and related data.
6. Effective presentation and improve soft skills.

METHOD OF EVALUATION:

During the seminar session each student is expected to prepare and present a topic on recent technological developments with respect to technical publications, for duration of about 15 to 20 minutes.

In a session of a period per week, students are expected to present the seminar.

Each student is expected to present at least once during the semester and the student is evaluated based on their performance.

At the end of the semester, He / She will submit a report on His / Her topic of seminar and are awarded based on the report presentation. Evaluation is 100% Internal.

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THIRD SEMESTER

3MTE1: Programme Elective –V (i) RENEWABLE ENERGY TECHNOLOGIES

SECTION - A

Solar Energy: Flat plate and concentrating collectors- design, analysis and performance, applications. Thermal Power, Photovoltaic power; Economic Analysis

Tidal and Ocean Energy: Applications, Design aspects, Power generation methods, various cycles and analysis.

SECTION - B

Wind Energy: Atmospheric circulation, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Betz limit, WECS: classification, characteristics, application, design aspects

Geothermal Energy And Magneto Hydrodynamics: Study of various components, Performance and methods of energy conversion.

Nuclear Energy: Fusion and fission, study of various components, Design aspects, performance and methods of power generation.

Text Books :

1. Power Plant Technology by El- Wakil, McGraw Hill publication.

2. Solar Energy : Fundamentals and Applications (1st Revised Edition), Tata McGraw-Hill,

References :

1. Solar Energy: Principles of thermal collection and Storage by Suhas P. Sukhatme ,Second Edition, Tata McGraw-Hill, 2006
2. Principles of Solar Thermal Engineering by F.Kreith& J .F.Kreider, McGraw Hill Publications 1978.
3. Solar Engineeering of thermal Processes by J .A.Duffie and W.A.Beckman, John Wiley & Sons publication 1999.
4. Applied Solar Energy by A.B.Meinal&F.P.Meinal, Addison Wesley 1976 publication.

3MTE1: Programme Elective –V

(ii) HYDROGEN AND FUEL CELL TECHNOLOGIES

Course Objectives:

1. To provide comprehensive and logical knowledge of hydrogen production, storage and applications.
2. To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics.
3. To study the cost effectiveness and eco-friendliness of Fuel Cells.

Course Outcomes:

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

1. Explain the importance of hydrogen energy as an alternative fuel
2. Describe the various methods of hydrogen production
3. Design hydrogen storage systems
4. Select appropriate fuel cell technology for a given application
5. Evaluate the performance of various types of fuel cells under different operating conditions
6. Develop suitable hydrogen systems to be used along with fuel cell system

SECTION – A

UNIT I: Introduction to Hydrogen energy:
Properties of hydrogen as fuel, Physical and chemical properties of hydrogen gas; overview of hydrogen energy utilization; Hydrogen sensing- methods of hydrogen using thermal conductivity measurements or Gas chromatography, mass spectrophotometry or laser gas analysis.

UNIT-II: Hydrogen Production: Thermal-steam reformation, gasification, pyrolysis, thermo-chemical water splitting, nuclear thermal catalytic and partial oxidation methods; Electrochemical-electrolysis, photo-electro chemical; Biological-anaerobic digestion, fermentation, PM based electrolyser.

UNIT III:Hydrogen Storage and Applications
Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage –
Comparisons; Safety and management of hydrogen; different materials for storage-metal hydrides, high surface area materials, complex and chemical hydrides; hydrogen storage system-design and material aspects Applications of Hydrogen.

SECTION – B

UNIT IV: Basics of Fuel Cell Technology:
History, principle, working of fuel cells, thermodynamics and kinetics of fuel cell process; performance and evaluation of fuel cell; Comparison of battery and fuel cells.

UNIT V: Fuel Cell Types:
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits.

UNIT VI: Applications of Fuel Cell and Economics:
Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space.
Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

Text Books:

1. Viswanathan B. and AuliceScibioh.M, Fuel Cells – Principles and Applications, UniversitiesPress, 2006.
2. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
3. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New YorkLtd., London 1989.
4. Srinivasan, S., “Fuel Cells – From Fundamentals to Applications”, Springer., 2006

Reference Books:

1. Baker BS, Hydrogen Fuel cell Technology, Academic Press, New York
2. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.
3. Bent Sorensen, Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.
4. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.

3MTE1: Programme Elective –V

(iii) FINITE ELEMENT METHOD

SECTION - A

Introduction:
Overview of numerical methods - Discretized representation of physical systems - thermal resistance, flow resistance networks, thermal capacitance - Governing equations and Boundary conditions for thermal and flow systems.

One Dimentional Heat Conduction:
Principles of variations calculus - applications of vibrational approach to one dimensional heat conduction -element matrix contribution andassembly.

Heat Functions And Analysis:
Weighted residual methods - Galerkin’s approach - Shape functions and interpolations - Application of Galerkin’s weighted residual approach toone dimensional heat conduction - Three nodded triangular elements, 2D steady state, state conduction using triangular elements – Radiationand natural convective boundary conditions - incorporation of variationsin thermal properties.

SECTION - B

Convective Heat Transfer:
Higher order elements and numerical integration solution of heatconduction and creeping flow using higher order element - Solution ofconvective heat transfer.

Heat Exchanger Applications:
Incompressible laminar flow simulation - Stream function/Vorticity methods, Velocity Pressure formulation, mixed order interpolation for incompressible flow, modifications for turbulent flow. Application to heat exchanger.

Software Codes:
Description of programs for heat conduction, fluid flow, Assignment problems using these codes.

Text Books :

1. The Finite Element Method in Engg., 2nd ed. S.S.RaoPergamonPress, 1990.
2. Applied Finite Element Analysis, 2nd ed, Larry Segerlind JohnWiley & Sons, 1988.
3. Finite Element Analysis Theory and Programming 2nd ed,C.S.Krishnamoorthy, Tata mcgraw-Hill 1991.
4. Finite Elements Methods, J.N.Reddy, mcgraw-Hill 1988.
5. Finite Element Methods O.C.Zienkiewiez, mcgraw-Hill 1980.
6. Introduction to Finite Elements in Engg.,T.R.Chandrapatla and Belegundu, Prentice Hall of India.
7. Finite Element Computational Fluid Mechanics - A.J.Baker, mc-graw-Hill.

3MTE2: Open Elective (i) BUSINESS ANALYTICS

Course Objectives:
1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Course Outcomes:
1. Demonstrate knowledge of data analytics.
2. Demonstrate ability of think critically in making decisions based on data and deep analytics
3. Demonstrate ability to use technical skills in predicative and prescriptive modeling to business decision-making.
4.Demonstrate the ability to translate data into clear, actionable insights.

SECTION-A

Unit-I: Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.
Unit-II: Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit-III: Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

SECTION-B

Unit IV: Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression. Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit V: Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit VI: Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Books Recommended:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education

3MTE2: Open Elective (ii) INDUSTRIAL SAFETY

Course Objectives:

1. To impart knowledge on safety engineering fundamentals and safety management practices.
2. To provide information regarding different elements of industrial water pollution and methods of treatment.
3. To understand about mechanical, electrical and chemical safety
4. To understand controlling of fire by various means
5. To expose to the various industrial applications, maintenance, preventive measures taken.

Course Outcomes:

1. Know how to take safety measures in executing works
2. Identify the need for maintenance (or) replacement of equipment
3. Understand the need for periodic and preventive maintenance
4. Identify and prevent chemical, environmental mechanical, fire hazard through analysis
5. Apply proper safety techniques on safety engineering and management.

SECTION-A

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

SECTION-B

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Books Recommended:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London

3MTE2: Open Elective (iii) OPERATIONS RESEARCH

Course Objectives:

1. Understand the methodology, model formulation of OR problem solving
2. Formulate linear programming problem and finding solutions
3. Understand Nonlinear programming problem and CPM/PERT
4. Understand project management techniques help in planning and scheduling a project
5. Understand basics of dynamic programming and simulation

Course Outcomes:
1. Apply the optimization techniques to solve problems of variables
2. Apply the concept of non-linear programming
3. Carry out sensitivity analysis
4. Apply project management techniques help in planning and scheduling a project
5. Apply sequencing and inventory control models models
6. Model the real world problem and simulate it.

SECTION-A

Unit I: Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit II: Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit III:Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

SECTION-B

Unit IV: Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit V: Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

Books Recommended:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

3MTE2: Open Elective (iv) COST MANAGEMENT OF ENGINEERING PROJECTS

Course Objectives:
1. To attain knowledge in Cost Management process and Costing System.
2. Ability to understand the basic concepts of Project planning, execution, and cost control
3. Discuss about Various types of costs and its behaviour along with Quality Management
4. Identify various types of Budgets involved in Cost Management process
5. Broaden the career potential of available techniques and problems available in Cost Management.

Course Outcomes:
1. Discuss various construction costs to manage a construction project.
2. Summarize different construction activities and its application related to cost based on the field requirements.
3. Identify Cost Behaviour of various types of cost and Quality Management
4. Identifying various construction Budgets involved Cost Management process.
5. Discussing various types of Techniques and Problem-solving techniques involved in Construction.

SECTION-A

Unit-I: Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-II: Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. DetailedEngineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit-III: Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

SECTION-B

Unit-IV: Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis.

Unit-V: Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Unit-VI: Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

Books Recommended:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

3MTE2: Open Elective (v) COMPOSITE MATERIALS

Course Objectives:

1. Introduce modern composite materials and their applications and classification.
2. Equip with knowledge on composite strengthening addition of components and their production routes.
3. Train to be able to design composite structures, select composite materials.
4. Understand process of development of different composite materials with advances manufacturing techniques
5. Develop an understanding of the linear elastic analysis of composite materials.
6. Familiarize about the properties and response of composite structures subjected to mechanical loading.

Course Outcomes:

1. Explain the advantages and applications of composite materials.
2. Describe the properties of various reinforcements of composite materials.
3. Summarize the manufacture of metal matrix, ceramic matrix and C-C composites.
4. Describe the manufacture of polymer matrix composites.
5. Formulate the failure theories of composite materials.

SECTION-A

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT–II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT–III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

SECTION-B

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT–V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Books Recommended:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
3. Hand Book of Composite Materials-ed-Lubin.
4. Composite Materials – K.K.Chawla.
5. Composite Materials Science and Applications – Deborah D.L. Chung.
6. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

3MTE2: Open Elective (vi) WASTE TO ENERGY

Course Objectives

1. To enable students to understand of the concept of waste to energy.
2. To link legal, technical and management principles for production of energy form waste.
3. To learn about the best available technologies for waste to energy.
4. To analyze of case studies for understanding success and failures.

Course Outcomes:

1. Apply the knowledge about the operations of waste to energy plants.
2. Analyze the various aspects of waste to energy management systems.
3. Carry out Techno-economic feasibility for waste to energy plants.
4. Apply the knowledge in planning and operations of waste to energy plants.

SECTION-A

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

SECTION-B

Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

Books Recommended:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996

3MTE3 : Dissertation Phase-I (SEMESTER-III) and 4MTE1 Dissertation Phase-II (SEMESTER-IV)

Course Objectives:

1. Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.

2. Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.

3. Ability to present the findings of their technical solution in a written report.

4. Presenting the work in International/ National conference or reputed journals.

Course Outcomes:

1. Design a research investigation that incorporates appropriate theoretical approaches, conceptual models, and a review of the existing literature.

2. Structure a discussion in a coherent and convincing way by summarizing the key arguments and providing suitable and coherent findings.

3. Draw valid conclusions, relating them to the research topic.

4. Write a comprehensive review of the literature, including a review of other dissertation research related to their study.

5. Develop a design of their study with a discussion of the methodology to be used. Students describe how their data will be treated and analyzed of their study.

Syllabus Contents:

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following:

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domains

The student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.

It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.
- The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase- I and II:

• As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.

• The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.

• After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.

• Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.

• Phase-I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

• Phase-I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the phase-I work.

• During Phase-II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

• Phase-II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.

• Phase-II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work.

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