JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE & SYLLABUS M.Tech ME for THERMAL SCIENCES AND ENERGY SYSTEMS PROGRAMME

(Applicable for batches admitted from 2019-2020)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

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KAKINADA – 533 003, Andhra Pradesh, India

I-SEMESTER

S.No	Code	Subject		L	T	P	Credits
1	TES 101(Core-1)	Advanced Heat Transfer		3	0	0	3
2	TES102(Core-2)	Computational Fluid Dynamics		3	0	0	3
3	Program Elective – I TES 103	TES 1031	Advanced I.C engine ,Electric and Hybrid vehicles	3	0	0	3
		TES 1032	Refrigeration and Cryogenics				
		TES 1033	Thermal and Nuclear Power Plants				
		TES 1034	Advanced Thermodynamics				
4	Program Elective – II TES 104	TES 1041	Advanced Fluid Mechanics	3	0	0	3
		TES 1042	Thermal Measurements and Process Controls				
		TES 1043	Alternative Fuel Technologies				
		TES 1044	Gas Turbines and Jet Propulsion				
5	TES 105	Computational Fluid Dynamics Lab		0	0	3	2
6	TES 106	Thermal Engineering Lab		0	0	3	2
7	TES 107	Research Methodology and IPR		2	0	0	2
8	TES 108	Soft Skills		2	0	0	0
		Total					**18**

II -SEMESTER

S. No	Code	Subject		L	T	P	Credits
1	TES 201(Core-1)	Solar Energy and Fuel Cell Technologies		3	0	0	3
2	TES 202(Core-2)	Energy Conservation and Management		3	0	0	3
3	Program Elective– III TES 203	TES 2031	Energy Systems Modeling and Analysis	0	0	3	3
		TES 2032	Energy Economics and Planning				
		TES 2033	Optimization Techniques and Applications				
		TES 2034	Biomass, Wind and Ocean Energy				
4	Program Elective– IV TES 204	TES 2041	Waste Heat Recovery Systems	0	0	3	3
		TES 2042	Design of Heat Transfer Equipment				
		TES 2043	Combustion, Emissions and Environment				
		TES 2044	Green Buildings				
5	TES 205	Modeling and Simulation lab		0	0	3	2
6	TES 206	Energy Systems lab		0	0	3	2
7	TES 207	Mini Project with Seminar		2	0	0	2
8	TES 208	Value Education		2	0	0	0
		Total					**18**

III - SEMESTER

<table>
<tr><th>S. No</th><th></th><th colspan="3">Subject</th><th>L</th><th>T</th><th>P</th><th>Credits</th></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Program Elective– V
TES 301</td><td>TES 3011</td><td>Design and Analysis of Experiments</td><td rowspan="4">(OR)
MOOCS/ NPTEL certification courses</td><td rowspan="4">3</td><td rowspan="4">0</td><td rowspan="4">0</td><td rowspan="4">3</td></tr>
<tr><td>TES 3012</td><td>Convective Heat Transfer</td></tr>
<tr><td>TES 3013</td><td>Advanced Finite Element Methods</td></tr>
<tr><td>TES 3014</td><td>Materials and Devices for Energy Applications</td></tr>
<tr><td>2</td><td>Open Elective
TES 302</td><td colspan="3">Students are advised to opt for an open elective course of their choice being offered by other Departments of the Institute
(OR)
MOOCS/NPTEL certification courses duly approved by the Department</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>3</td><td>TES 303</td><td colspan="3">Dissertation phase –I</td><td>0</td><td>0</td><td>20</td><td>10</td></tr>
<tr><td colspan="8">Total</td><td>16</td></tr>
</table>

IV - SEMESTER

S. No	Subject	L	T	P	Credits
1	Dissertation phase –II	0	0	32	16

M.Tech - I Sem		L	T	P	C
		3	0	0	3

ADVANCED HEAT TRANSFER

UNIT-I:

BRIEF INTRODUCTION TO DIFFERENT MODES OF HEAT TRANSFER: Conduction: General heat Conduction equation-initial and boundary conditions.

Transient heat conduction: Lumped system analysis-Heisler charts-semi infinite solid-use of shape factors in conduction-2D transient heat conduction-product solutions.

UNIT- II:

FINITE DIFFERENCE METHODS FOR CONDUCTION: One dimensional & two dimensional steady state and simple transient heat conduction problems-implicit and explicit methods.

Forced Convection: Equations of fluid flow-concepts of continuity, momentum equations-derivation of energy equation-methods to determine heat transfer coefficient: Analytical methods-dimensional analysis and concept of exact solution. Approximate method-integral analysis.

UNIT-III:

EXTERNAL FLOWS: Flow over a flat plate: integral method for laminar heat transfer coefficient for different velocity and temperature profiles. Application of empirical relations to variation geometries for laminar and turbulent flows.

Internal flows: Fully developed flow: integral analysis for laminar heat transfer coefficient- types of flow-constant wall temperature and constant heat flux boundary conditions- hydrodynamic & thermal entry lengths; use of empirical correlations.

UNIT-IV:

FREE CONVECTION: Approximate analysis on laminar free convective heat transfer-boussinesq approximation-different geometries-combined free and forced convection.

Boiling and condensation: Boiling curve-correlations-Nusselts theory of film condensation on a vertical plate-assumptions & correlations of film condensation for different geometries.

UNIT-V:

RADIATION HEAT TRANSFER: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames.

TEXT BOOKS:

1. Heat and Mass Transfer: Fundamentals and Applications/Yunus Cengel/ McGraw-Hill Science/Engineering/Math; 5 edition
2. Heat Transfer / Necati Ozisik / TMH
3. Fundamentals of Heat and Mass Transfer/Tirumaleshwar/Dorling Kindersley Pvt Ltd

REFERENCES:

1. Fundamentals of Heat and Mass Transfer-5th Ed. / Frank P. Incropera/John Wiley
2. Elements of Heat Transfer/E. Radha Krishna/CRC Press/2012
3. Introduction to Heat Transfer/SK Som/PHI
4. Heat Transfer / Nellis & Klein / Cambridge University Press / 2012.
5. Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press
6. Engg. Heat & Mass Transfer/ Sarit K. Das/Dhanpat Rai
7. Heat Transfer/ P.K.Nag /TMH
8. Heat Transfer / J.P Holman/MGH

M.Tech - I Sem		L	T	P	C
		3	0	0	3

COMPUTATIONAL FLUID DYNAMICS

UNIT – I

INTRODUCTION: Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

SOLUTION METHODS: Solution methods of elliptical equations – finite difference formulations, interactive solution methods, direct method with Gaussian elimination.

Parabolic equations, explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

UNIT – II

HYPERBOLIC EQUATIONS: Explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations.

Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

UNIT – III

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

TREATMENT OF COMPRESSIBLE FLOWS: Potential equation, Eluer equations, Navier-Stokes system of equations, flow-field, dependent variation methods, boundary conditions.

UNIT – IV

FINITE VOLUME METHOD: Finite volume method via finite difference method, formulations for two and three, dimensional problems.

UNIT – V

STANDARD VARIATIONAL METHODS: Linear fluid flow problems, steady state problems, Transient problems.

TEXT BOOKS:

1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.
2. Computational Fluid Dynamics by John D. Anderson, McGraw Hill Book Company 2017.

REFERENCE:

1. Text book of fluid dynamics, Frank Chorlton, CBS Publishers &distributors, 1985.
2. Computational Techniques for Fluid Dynamics, Volume 1& 2 By C. A. J. Fletcher, Springer Publication, 2012.

M.Tech - I Sem		L	T	P	C
		3	0	0	3
ADVANCED I.C ENGINE ELECTRIC AND HYBRID VECHILES					

UNIT-I:

GAS EXCHANIGING PROCESSES:

Inlet and exhaust processes in the four stroke cycle volumetric efficiency quasi static effects combined quasi static and dynamic effects variation with speed and valve area lift and timing –flow through valves poppet valve geometry and timing flow rate and discharge coefficients, residual gas fraction , exhaust gas flow rate and temperature variation, scavenging in two stroke cyclic engines, scavenging parameters and models actual scavenging processes , flow through ports, super charging and turbo changing – methods of power boosting basic relationships compressors, turbines wave compression devices.

UNIT-II:

CHARGE MOTION WITHIN THE CYLINDER:

Intake Jet Flow, Mean velocity and turbulence characteristics definitions application to engine velocity data swirl – swirl measurement, swirl generation during induction swirl modification within the cylinder squish pre chamber engine flows crevice flows and blowby flows generated
by piston –cylinder wall interaction.

UNIT-III:

COMBUSTION IN S.I AND C.I ENGINES:

Review of normal and abnormal combustion in SI and CI engine cyclic variation in combustion of SI engine , analysis of cylindrical pressure data in SI and CI engine ,MPFI in SI engines common rail fuel injection system in CI engines fuel spray behavior in CI engines.

UNIT- IV:

ELECTRIC VEHICLES:

Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure, Electric vehicle drive train, advantages and limitations, Permanent magnet and switched reluctance motors

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

UNIT- V:

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

FUEL CELL VECHILES: Introduction, Fuel cell characteristics, Thermodynamics of fuel cells, Fuel cell types: emphasis on PEM fuel cell.

TEXT BOOKS:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988

2. Seth Leitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.

3. F. Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press,2005.

REFERENCES:

1. W.W. Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt. Ltd 2002

M.Tech - I Sem		L	T	P	C
		3	0	0	3
REFIGERATION AND CRYOGENICS					

Unit-I: VAPOUR COMPRESSION REFRIGERATION SYSTEMS:

Analysis of vapour compression refrigeration cycle

COMPOUND VAPOUR COMPRESSION SYSTEM: Removing of flash gas – inter cooling compound compression ultra water inter cooler -liquid flash cooler – flash inlet cooler, multiple evaporator and compression systems, one compressor system – individual compressors compound compression – cascade systems.

Unit-II: ABSOPTION REFRIGERATION SYSTEM WITH MULTIPLE EVOPARATORS

Three fluid absorption systems-the Lithium Bromide water absorption system, Steam jet water vapour systems – thermoelectric refrigeration systems – vortex refrigeration system – pulse tube refrigeration.

Desirable properties of refrigerants – designation of refrigerants – inorganic, halo carbon refrigerants – inorganic halo carbon reactions- secondary refrigerants – reaction of refrigerants with moisture and oil – properties of mixtures of refrigerants – ozone depletion potential and global warming potential of CFC refrigerants – substitutes for CFC refrigerants

Unit-III : CRYOGENICS

Introduction necessity of low temperature - Multistage Refrigeration system -Cascade system - Manufacture of dry ice-Joule Thompson coefficient. Liquification of air - Linde system- Analysis- Dual pressure cycle analysis-Liquefaction of Hydrogen and Helium-problems.

UNIT-IV: APPLICATION OF LOWER TEMPERATURES

Effects on the properties of metals-strength-Thermal properties-super conductivity-super fluidity. Applications like expansion fitting - cryobiology-cryosurgery - space research-computers under ground power lines.

UNIT- V: LOW TEMPERATURE INSULATION

Reflective insulation-Evacuated powders-Rigid foams-Super insulation. Cooling by adiabatic de-magnetization - Gas separation and cryogenic systems separation of gases- Rectifying columns-Air separating- single and double columns Air separation plant.

Storage and handling of cryogenic liquids - Dewars and other types of containers

TEXT BOOKS:

1. C.P. Arora, Refrigeration & Air-Conditioning by TMH
2. R.F Barron ,Cryogenic Systems , Oxford University Press .

REFERENCE BOOKS:

1. Stoecker W.F.Refrigeration & Air-Conditioning, and Jones, J.W., McGraw Hill
2. Manohar Prasad, Refrigeration & Air-Conditioning , New Age .Domkunduwar,
3. 3. Refrigeration & Air-Conditioning and Arora , Dhanpatrai & Sons

M.Tech - I Sem		L	T	P	C
		3	0	0	3

THERMAL AND NUCLEAR POWER PLATS

UNIT I

Energy scenario, overview of steam power plant, Analysis of steam cycles, Feed water heaters. De-aerator and drain cooler, optimization of cycle parameters, reheat and regeneration, Analysis of multi-fluid coupled cycles, Cogeneration of power and process heat, Combined cycle power generation.

UNIT II

Fuels, Combustion mechanisms, Draft systems, Combustion control, Furnaces for burning coal in fluidized beds and in pulverized form, Coal handling installation, Different types of boilers and their specific uses, Boiler mountings and accessories, Feed water treatment.

UNIT III

Boiler maintenance, Circulation theory, Downcomers and risers, Drum and its internals, Economiser, Convective and radiant super heaters, Superheat temperature control, Recuperative and regenerative air preheaters, Dust and ash removal systems, Environmental aspects of power generation

UNIT IV

Basic concepts of reactor physics, radioactivity, Neutron Scattering, Thermal and fast reactors, Nuclear cross-sections, Neutron flux and reaction rates, Moderator criteria, Reactor core design, Conversion and breeding, Types of reactors, Characteristics of boiling water, pressurized water, pressurized heavy water, gas cooled and liquid metal cooled reactors.

UNIT V

Future trends in reactor design and operation, Thermal-hydraulics of reactors, Heavy water management, Containment system for nuclear reactor, Reactor safety radiation shields, Waste management, Indian nuclear power programme.

TEXT BOOKS:

1. M.M.EI. Wakil., _Nuclear Power Engineering', McGraw Hill Book Company, New York, 1987.
2. S. Glasstone and A. Setonske., _Nuclear Reactors, Engineering', 3rd Ed., CBS Publishers and Distributors, 1992.

REFERENCES:

1. Loftness, _Nuclear Power Plants', D. Van Nostrand Company Inc, Princeton, 1964.
2. S. Sarg et al., _Physics of Nuclear Reactors', Tata McGraw Hill Publishing Company Ltd., 1985.
3. T. J. Connoly., _Fundamentals of Nuclear Energy', John Wiley, 1978

M.Tech - I Sem		L	T	P	C
		3	0	0	3

ADVANCED THERMODYNAMICS

UNIT-I

AVAILABILITY AND IRREVERSIBILITY: Quality of Energy, available and unavailable energy, availability, surroundings work, reversible work and irreversibility, availability in a closed system, availability in a SSSF process in an open system, second law efficiencies of processes, second law efficiency of cycles and exergy balance equations.

UNIT-II

THERMODYNAMIC PROPERTY RELATIONS: Helmholtz and Gibbs Functions, two Mathematical Conditions for Exact Differentials, Maxwell Relations, Clapeyron Equation, Relations for Changes in Enthalpy, Internal Energy and Entropy, Specific Heat Relations, Generalized Relations/Charts for Residual Enthalpy and Entropy, Gibbs Function at zero Pressure: A Mathematical Anomaly, Fugacity, Fugacity Coefficient and Residual Gibbs Function, The Joule, Thomson Coefficient and Inversion Curve, Thermodynamic similarity.

UNIT-III

NON-REACTING MIXTURES OF GASES AND LIQUIDS: Measures of Composition in Multi Component Systems.

Gas Mixtures: Mixtures of ideal Gases, Gas-Vapor Mixtures, Application of First Law to Psychometric Processes, Real Gas Mixtures.

Liquid Mixtures/Solutions: Ideal Solutions, Real Solutions.

Thermodynamic Relations for Real Mixtures: Partial Properties, Relation for Fugacity and Fugacity Coefficient in Real Gas Mixtures, Relations for Activity and Activity Coefficient in Real Liquid Mixtures/Solutions.

UNIT-IV

PHASE EQUILIBRIUM :VAPOUR LIQUID EQUILIBRIUM OF MIXTURES: Phase Diagrams for Binary Mixtures, Vapor, Liquid Equilibrium in Ideal Solutions, Criteria for Equilibrium, Criterion foe phase Equilibrium, Calculation of Standard State Fugacity of Pure Component, Vapor Liquid Equilibrium at Low to Moderate Pressures, Determination of Constants of Activity Coefficient Equations, Enthalpy Calculations.

UNIT-V

CHEMICAL REACTIONS AND COMBUSTION: Thermo chemistry, Measures of Composition in Chemical Reactions, Application of First Law of Thermodynamics to chemical Reactions, the Combustion Process-Standard Heat/Enthalpy of Combustion, Reactions at actual Temperatures, adiabatic Flame Temperature, Entropy Change of Reacting Systems, Application of second Law of Thermodynamics to chemical Reactions,chemical equilibrium-Advancement of Chemical Reactions, Equilibrium Criterion in Chemical Reactions, equilibrium Constant and Law of Mass Action, Equilibrium Constant for Gas Phase Reactions in the standard state.

TEXT BOOKS:

1. Basic and Applied Thermodynamics, P.K.Nag, TMH, 2019.
2. Thermodynamics, J.P Holman, Mc Graw Hill, 2017.
3. Thermodynamics ,CP Arora, Mc Graw Hill education (India pvt limited), 2016.

REFERENCES:

1. Engg. Thermodynamics, PL.Dhar, Elsevier, 2008.
2. Thermodynamics, Sonnatag & Van Wylen, John Wiley & Sons, 2004.
3. Thermodynamics for Engineers, Doolittle-Messe, John Wiley & Sons, 2018.
4. Irreversible thermodynamics, HR De Groff, .
5. Thermal Engineering, Soman, PHI, 2011.
6. Thermal Engineering, Rathore, TMH, 2010.

   Engineering Thermodynamics, Chatopadyaya, 2010.

M.Tech - I Sem		L	T	P	C
		3	0	0	3

ADVANCED FLUID MECHANICS

UNIT -I:

INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerain Descriptions of fluid motion, Path lines, Stream lines, Streak lines, stream tubes – velocity of a fluid particle, types of flows, Equations of three dimensional continuity equation, Stream and Velocity potential functions.

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

UNIT -II:

Viscous Flow: Derivation of Navier,v Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poisoulle flow, Coutte flow with and without pressure gradient , Hagen Poisoulle flow, Blasius solution.

UNIT -III:

Boundary Layer Concepts : Prandtl's contribution to real fluid flows – Prandtl's boundary layer theory , Boundary layer thickness for flow over a flat plate – Approximate solutions – Creeping motion (Stokes) – Oseen's approximation , Von,Karman momentum integral equation for laminar boundary layer –– Expressions for local and mean drag coefficients for different velocity profiles.

UNIT- IV:

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

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

UNIT -V:

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

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

TEXT BOOKS:

1. Fluid Mechanics / L.VictorSteeter / TMH
2. Fluid Mechanics / Frank M.White / MGH

REFERENCES:

1. Fluid Mechanics and Machines/Modi and Seth/Standard Book House
2. Fluid Mechanics/Cohen and Kundu/Elsevier/5th edition
3. Fluid Mechanics/Potter/Cengage Learning
4. Fluid Mechanics/William S Janna/CRC Press
5. Fluid Mechanics / Y.A Cengel and J.M Cimbala/MGH
6. Boundary Layer Theory/ Schlichting H /Springer Publications
7. Dynamics & Theory and Dynamics of Compressible Fluid Flow/ Shapiro.
8. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH
9. Fluid Mechanics / K.L Kumar /S Chand & Co.

M.Tech - I Sem		L	T	P	C
		3	0	0	3

THERMAL MEASUREMENTS AND PROCESS CONTROLS

UNIT-I

GENERAL CONCEPTS: Fundamental elements of a measuring instruments. Static and dynamic characteristics – errors in instruments – Different methods of measurement and their analysis – Sensing elements and transducers.

Measurement of pressure – principles of pressure measurement, static and dynamic pressure, vacuum and high pressure measurement – Measurement of low pressure, Manometers, Calibration methods, Dynamic characteristics, design principles.

UNIT-II

MEASUREMENT OF FLOW: Obstruction meters, variable area meters, Pressure probes, compressible fluid flow measurement, Thermal anemometers, calibration of flow measuring instruments. Introduction to design of flow measuring instruments.

UNIT-III

TEMPERATURE MEASUREMENT: Different principles of Temperature Measurement, use of bimetallic thermometers – Mercury thermometers, Vapor Pressure thermometers, Thermo positive elements, thermocouples in series & parallel, pyrometry, measurement of heat flux, calibration of temperature measuring instruments. Design of temperature measuring instruments.

MEASURMENT OF : Velocity, moisture content , humidity and thermal conductivity .

UNIT-IV

VOLTAGE INDICATING, RECORDING AND DATA ACQUISITION SYSTEMS: Standards and calibration, analog volt meters and potentiometers. Electrical instruments. Digital voltmeters and millimeters. Signal generation. Electro mechanical servo type XT and XY recorders. Thermal array recorders and data acquisition systems. Analog and digital CROs. Displays and liquid crystals flat panel displays. Displays. Virtual instruments. Magnetic tape and disk recorders/reproducers. Fiber optic sensors.

UNIT-V

PROCESS CONTROL: Introduction and need for process control principles, transfer functions, block diagrams, signal flow graphs, open and closed loop control systems – Analysis of First & Second order systems with examples of mechanical and thermal systems.

Control System Evaluation – Stability, steady state regulations, transient regulations.

TEXT BOOK:

1. Measurement System, Application & Design – E.O. Doeblin, MGH

REFERENCES:

1. Mechanical and Industrial Measurements – R.K. Jain – Khanna Publishers.
2. Mechanical Measurements – Buck & Beckwith – Pearson.
3. Control Systems, Principles & Design, 2nd Edition – M. Gopal – TMH.
4. Mechanical Measurements – J.P Holman

M.Tech - I Sem		L	T	P	C
		3	0	0	3

ALTERNATIVE FUEL TECHNOLOGIES

UNIT I

Fossil fuels and their limitations; Engine requirements; Potential alternative liquid and gaseous fuels.

UNIT II:-

Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di-methyl and Di-ethyl ether etc.

UNIT III:-

Different ways of using alternative liquid fuels in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance.

UNIT IV:-

Use of gaseous fuels like biogas, LPG, hydrogen, natural gas, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels.

UNIT V:-

Different approaches like duel fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

TEXT BOOK:

1. Alternative Fuels: The Future of Hydrogen, Second Edition**,** Michael Frank Hordeski, CRC Press

REFERENCES:

1. Alternative Fuels for Transportation, A S Ramadhas, CRC Press
2. Alternative Fuels & Advanced Technology Vehicles: Incentives & Considerations, Thomas Huber, Jack Spera, Nova Science Publishers

M.Tech - I Sem		L	T	P	C
		3	0	0	3

GAS TURBINES AND JET PROPULSION

UNIT-I

Introduction to gas dynamics: control volume and system approaches acoustic waves and sonic compressibility factor - general features of one dimensional flow of a compressible fluid - continuity and momentum equations for a control volume, Isentropic flow of an ideal gas: basic equation - stagnation enthalpy, temperature, pressure and density-stagnation, acoustic speed - critical speed of sound- dimensionless velocity-governing equations for isentropic flow of a perfect gas - critical flow area - stream thrust and impulse function.

UNIT-II

Steady one dimensional isentropic flow with area change-effect of area change on flow parameters-chocking- convergent nozzle - performance of a nozzle under decreasing back pressure -De lavel nozzle - optimum area ratio effect of back pressure - nozzle discharge coefficients - nozzle efficiencies, Simple frictional flow: adiabatic flow with friction in a constant area duct-governing equations - fanno line limiting conditions - effect of wall friction on flow properties in an Isothermal flow with friction in a constant area duct-governing equations - limiting conditions.

UNIT-III

Steady one dimensional flow with heat transfer in constant area ducts- governing equations - Rayleigh line entropy change caused by heat transfer - conditions of maximum enthalpy and entropy, Effect of heat transfer on flow parameters: Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas-properties of flow across a normal shock - governing equations - Rankine Hugoniat equations - Prandtl's velocity relationship - converging diverging nozzle flow with shock thickness - shock strength.

UNIT- IV

Propulsion: Air craft propulsion: - types of jet engines - energy flow through jet engines, thrust, thrust power and propulsive efficiency turbojet components-diffuser, compressor, combustion chamber, turbines, exhaust systems.

UNIT – V

Performance of turbo propeller engines, ramjet and pulsejet, scramjet engines. Rocket propulsion - rocket engines, Basic theory of equations - thrust equation - effective jet velocity - specific impulse - rocket engine performance - solid and liquid propellant rockets - comparison of various propulsion systems.

TEXT BOOKS

1. Compressible fluid flow - A. H. Shapiro
2. Fundamentals of compressible flow with aircraft and rocket propulsion- S. M. Yahya

REFERENCES

1. Elements of gas dynamics - Liepman & Roshko
2. Aircraft & Missile propulsion - Zucrow
3. Gas dynamics - M.J. Zucrow & Joe D.Holfman

M.Tech - I Sem		L	T	P	C
		0	0	3	2

COPUTATIONAL FLUID DYNAMICS LAB

M.Tech - I Sem		L	T	P	C
		3	0	0	3

THERMAL ENGINEERING LAB

M.Tech - I Sem		L	T	P	C
		3	0	0	3
RESEARCH METHODOLOGIES AND IPR					

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

UNIT-III

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-IV

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-V

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.

REFERENCES:

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

M.Tech - I Sem		L	T	P	C
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SOFT SKILLS

<table>
<tr><td rowspan="2">M.Tech - II Sem</td><td rowspan="2"></td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">SOLAR ENERGY AND FUEL CELL TECHNOLOGIES</td></tr>
</table>

UNIT-I: Introduction:

Solar energy option - Specialty and potential - Sun - Earth - Solar radiation - Beam and diffuse - Measurement - Estimation of average solar radiation on horizontal and tilted surfaces - Problems-Applications. Capturing solar radiation - Physical principles of collection - Types - Liquid flat plate and concentrating type collectors. Power generation - Solar central receiver system - Heliostats and receiver - Heat transport system- Solar distributed receiver system.

UNIT-II: Solar Thermal Energy Storage:

Introduction - Methods of sensible heat storage using solids and liquids - Packed bed storage - Latent heat storage - Working principle - Application and limitations - Solar devices - Stills - Air heaters - Dryers - Solar Ponds and Solar Refrigeration - Active and passive heating systems.

UNIT-III: Solar PV System Design and Applications:

Standalone PV systems - Lighting - Water pumping - Hybrid PV Systems - PV wind and PV diesel - Grid connected PV Systems - PV power plants - Roof top and ground mounted small & large power plants. Different types of PV Cell materials.

UNIT IV: LOW AND HIGH TEMPERATURE FUEL CELLS: Basic theory of electro chemistry. electro chemical energy conversion, electro chemical techniques. Proton exchange membrane fuel cell (PEMFC) and direct methanol fuel cell (DMFC): their special features and characteristics. Molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) for power generation, their special features and characteristics.

UNIT V: FUEL CELL SYSTEM DESIGN AND MODELLING: Principles of design of PEMFC, DMFC and SOFC. Fuel Cell System-Materials, component, stack, interconnects, internal and external reforming, system layout, operation and performance. Modeling- electro chemical model, heat and mass transfer model system thermo dynamic model

TEXT BOOKS:

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

REFERENCES:

1.J., Dick A., Fuel Cell Systems Explained, 2nd Ed. Wiley, 2003.
2.Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006).
3.Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y. (2004) Ref Book.
4.M.T.M. Koper (ed.), Fuel Cell Catalysis, Wiley, Larminie 2009.

M.Tech - II Sem		L	T	P	C
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ENERGY CONSERVATION AND MANAGEMENT

UNIT I:
The energy market, energy scenario, planning, utilization pattern and future strategy, Importance of energy management.

UNIT II:
ENERGY CONSERVATION: Methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems Energy conservation in industries, Cogeneration, Combined heating and power systems.

UNIT III:
ENERGY MANAGEMENT: Principles of Energy Management, Energy demand estimation, Organising and Managing Energy Management Programs, Energy pricing
Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries

UNIT IV:
ECONOMIC ANALYSIS: Scope, Characterization of an Investment Project

UNIT V:
Relevant international standards and laws.

TEXT BOOKS

1. L.C. Witte, P.S. Schmidt, D.R.Brown, “Industrial Energy Management and Utilization”, Hemispherical Publication, 1988.
2. Callaghan “Energy Conservation”.

REFERENCES:

1. D.A. Reeg, “Industrial Energy Conservation”, Pergamon Press, 1980.
2. T.L. Boyen, “Thermal Energy Recovery” Wiley, 1980.
3. L.J. Nagrath, “Systems Modeling and Analysis”, Tata McGraw Hill, 1982.
4. W.C. Turner, “Energy Management Handbook “, Wiley, New York, 1982.
5. I.G.C. Dryden, “The Efficient Use of Energy “, Butterworth, London, 1982.
6. R. Loftnen, Van Nostrarid Reinhold C. “Energy Handbook”, 1978.
7. TERI Publications.
8. WR Murphy, G McKay “Energy Management”

M.Tech - II Sem		L	T	P	C
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ENERGY SYSTEMS MODELING AND ANALYSIS					

UNIT-I: INTRODUCTION

Overview of various technologies and conventional methods of energy conversion, Designing a Workable System: Workable and optimum systems, Steps in arriving a workable system, Creativity in concept selection, Workable Vs Optimum system, Mathematical modeling, Polynomial representation, Functions of two variables, Exponential forms, Best fit Method of least squares

Unit-II: MODELING OF THERMAL EQUIPMENT

Counter flow heat exchanger, Evaporators and Condensers, Heat exchanger effectiveness, Effectiveness of a counter flow heat exchanger, NTU, Pressure drop and pumping power

SYSTEM SIMULATION:

Classes of simulation, Information flow diagrams, Sequential and simultaneous calculations, Successive substitution, Newton Raphson method

Unit-III: OPTIMIZATION TECHNIQUES

Mathematical representation of optimization problems, A water chilling system, Optimization procedure, Setting up the mathematical statement of the optimization problem, Dynamic Programming: Characteristic of the Dynamic programming solution, Apparently constrained problem, Application of Dynamic programming to energy system problems, Geometric Programming: One independent variable unconstrained, Multivariable optimization, Constrained optimization with zero degree of difficulty ,Linear Programming: Simplex method, Big-M method, Application of LP to thermal systems

Unit-IV: LAGRANGE MULTIPLIER'S METHOD:

The Lagrange multiplier equations, Unconstrained optimization, Constrained optimization, Sensitivity coefficients

SEARCH METHODS: Single variable – Exhaustive, Dichotomous and Fibonacci, Multivariable unconstrained - Lattice, Univariable and Steepest ascent

Unit-V: MATHEMATICAL MODELING

Thermodynamic properties-Need for mathematical modeling, Criteria for fidelity of representation, Linear regression analysis, Internal energy and enthalpy, Pressure temperature relationship at saturated conditions, Specific heat, P-V-T equations

TEX BOOKS :

1. W.F.Stoecker (1989),"Design of Thermal Systems" McGraw Hill, 3rd Ed.
2. B.K.Hodg(1990),"Analysis and Design of Thermal Systems", Prentice Hall Inc.,.

REFERENCE BOOKS

1.I.J.Nagrath & M.Gopal, "Systems Modelling and Analysis", Tata McGraw Hill.

2. D.J. Wide(1978), "Globally Optimal Design", Wiley- Interscience,

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ENERGY ECONOMICS AND PLANINIG

UNIT I: INTRODUCTION TO ENERGY ECONOMICS

Natural Resources – Classification – Importance – Role of Natural Resources in Economic Development – Energy Resources – Types and Classification – Properties of Energy – Forms of Energy – Emergence of Energy Economics – Its Scope and Nature – Energy Indicators - Energy Economics and its relations with other Branches.

UNIT II: ENERGY AND DEVELOPMENT

Role of Energy in Economic Development – Energy intensity and Energy Elasticity – National and International Comparison – Low, Middle, and High Income Economies – Role of International Institutions – OPEC, OAPEC, IEA, and World Bank.

UNIT III: ENERGY AND ENVIRONMENT

Energy Crisis – Causes and Consequences – Remedial Measures – Environmental Crisis – Causes and Consequences – Remedial Measures – Impact of Energy Consumption and Production on Environment with illustrations – Role of Energy and Environmental Economists in solving Energy the crises.

UNIT IV: ENERGY CONSERVATION AND ENERGY MANAGEMENT

Energy Planning and Energy Conservation – Meaning, Objectives and Importance – Energy Management – Meaning, Objectives and Importance – Recent Developments – Energy Auditing – Energy Accounting – Energy Pricing and Taxes – Role of Economists in Promoting Sustainable Energy Management.

UNIT V: INDIA'S ENERGY PROFILE

Indian Energy Sector – Organizational Structure – Energy Supply (Coal, Lignite, Oil, Gas and Powers – Hydro, Nuclear, Thermal) – Energy Demand (Agriculture, Industry, Transport, Domestic, etc) – Renewable Energy Sources and Technology (Solar, Wind, Biogas, Biomass, Geothermal, OTEC, Tidal, Wave Hydrogen, Fuel Cell, Bio-Diesel) – Renewable Energy Programmes – Energy Under Five Year Plans – Energy Issues and Policy Options for India.

TEXT BOOKS:

1. Agarwal, M.C. and Monga, J.R. (1992): **Economic and Commercial Geography**, National Publishing House, New Delhi.
2. **Agarwal, S.K. (1985):** Environment and Natural Resources Economics**, Scott Foresman & Co., London**

REFERENCES

1.Common, M. (1985) : **Environmental and Resource Economics**, Longman, London.
2.David Pearct et al., (1990) : **Sustainable Development – Economics and Environment in the Third World**, Earths Can Publications, London.
3.Deoffrey Kirk (1982) : **Schemacher on Energy**, Abacus, London.
4.Government of India (2002) : **Thenth Five Year Plan**, Planning Commission, New Delhi.
5. Hemalatha Rao (1990) : **Rural Energy Crises : A Diagnostic Analysis**, Ashish Publishing House, New Delhi.

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OPTIMIZATION TECHNIQUES AND APPLICATIONS					

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

UNIT - II
MULTI VARIABLE NON,LINEAR UNCONSTRAINED OPTIMIZATION: Direct search method,Univariant method , pattern search methods,Powell's, Hook ,Jeeves, Rosenbrock search methods, gradient methods, gradient of function, steepest decent method, Fletcher Reeves method, variable metric method.

UNIT - III
LINEAR PROGRAMMING: Formulation,Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. Duality,importance of duality, solution of primal from dual.

UNIT- IV
NON TRADITIONAL OPTIMIZATION ALGORITHMS: Genetics Algorithm,Working Principles, Similarities and Differences between Genetic Algorithm & Traditional Methods. Simulated Annealing, Working Principle,Simple Problems.

UNIT -V
APPLICATIONS TO THERMAL SYSTEMS: Optimal design of heat exchangers, condensers, evaporator and IC Engines.

TEXT BOOKS:
1. Optimization theory & Applications / S.S.Rao / New Age International.
2. Optimization for Engineering Design, Kalyanmoy Deb, PHI

REFERENCE BOOKS:
1. S.D.Sharma / Operations Research
2. Optimization Techniques /Benugundu & Chandraputla / Pearson Asia.
3. Design of Thermal Systems / W.F Stoecker/Mc Graw Hill Education

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BIOMASS, WIND AND OCEAN ENERGY

UNIT - I

Sources and classification - Chemical composition - Properties of biomass - Energy plantations - Size reduction - Briquetting - Drying - Storage and handling of biomass, Feedstock for biogas - Microbial and biochemical aspects - Operating parameters for biogas production

UNIT - II:

Thermo chemical conversion of lignocelluloses biomass - Incineration - Processing for liquid fuel production - Pyrolysis - Effect of particle size -Temperature and products obtained.

UNIT - III: WIND ENERGY: Wind Energy, Indian Wind Energy Potential, Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind Energy Conversion Systems : classification, characteristics, applications

UNIT - IV: WAVE ENERGY -CONCEPTS & RESOURCE:

Introduction - Terminology & concepts -Preliminary considerations - Oscillating water column - Sea states & their energy - Wave growth, travel & decay - Wave climate estimation - Numerical and experimental modeling of wave energy conversion systems - Wave tank and wave maker design - Laboratory testing of wave energy conversion systems - Case studies.

UNIT - V: WAVE ENERGY - POWER TAKE - OFF SYSTEMS:

Air turbine design for OWCS - Design configurations - Direct drive -Linear generator systems - Principles and case studies - Full scale WECS - LIMPET - Archimedes wave swing (AWS) - Pelamis & wave dragon - Design & implementation - Environmental impact - Legislation &administrative issues.

TEXT BOOKS:

1. "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Chakraverthy A, Oxford & IBH publishing Co, 1989
2. 'Ocean wave Energy –Current Status & Future Perspectives" by Crug Joao, springer, 2008.

REFERENCE BOOKS:

1. Solar Engineering of Thermal Processes, Duffie, A and Beckmann, W. A., John Wiley, 1991.
2. Renewable Energy Sources, Twidell, J.W. and Weir, A.,EFN Spon Ltd., 1983.
3. Magneto Hydrodynamics, Kuliovsky and Lyubimov, Addison.
4. "Renewable Energy, Power for a Sustainable Future", Edited by Godfrey
5. Boyle Oxford University Press, Third Edition 2012.
6. Wind Energy Conversion Systems, Freris, L.L., Prentice Hall, 1990

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WASTE HEAT RECOVERY SYSTEMS					

Unit-I: Integrated Solid Waste Management:

Solid waste in history - Economics and solid waste - Legislation and regulations - Materials flow - Reduction - Reuse - Recycling-Recovery - Disposal of solid waste in landfills - Energy conversion - The need for integrated solid waste management - Special wastes.

Unit-II: **Landfills**:

Planning, siting, and permitting of landfills - Planning - Siting - Permitting - Landfill processes - Biological degradation - Leachate production - Gas production - Landfill design - Liners - Leachate collection - Treatment and disposal - Landfill gas collection and use - Geotechnical aspects of landfill design – Storm water management - Landfill cap - Landfill operations - Landfill equipment - Filling sequences - Daily cover - Monitoring - Post closure care and use of old landfills - Landfill mining.

Unit-III: Sources of Effluent from the Process of Industries:

Manufacturing process and sources of effluent from the process of industries like chemical - Fertilizer - Petroleum - Petrochemical - Paper - Sugar - Distillery - Textile - Tannery - Food processing - Dairy and steel manufacturing - Characteristics and composition of effluent and different methods of treatment & disposal of effluent for the following industries steel - Petroleum refineries - Textiles - Tanneries - Atomic energy plants and other mineral processing industries.

Unit-IV: Waste Water Treatment Methods:

Nitrification and de-nitrification - Phosphorous removal - Heavy metal removal - Membrane separation process - Air stripping and absorption processes - Special treatment methods - Disposal of treated waste.

Unit -V: Environmental Issues in Agriculture:

Types of farming systems - Agro meteorology - Water and nutrients requirement - Fertilizers: Types of fertilizers - Pesticides and other agrochemicals - Soil and water conservation practices. Text Books:

TEXT BOOKS

1. Hand book of solid waste management and Waste Minimization Technologies. Nicholas P. Chermissionoff. An imprint of Elsevier, New Delhi (2003).
2. Solid Waste Engineering, P. AarneVesilind, William A. Worrell and Debra R. Reinhart. Thomason Asia Pte Ltd. Singapore (2002).

REFERENCE:

1. Industrial Waste Water Pollution Control, W. Wesley Eckenfelder Jr., McGraw-Hill, 2000.
2. Wastewater Treatment for Pollution Control, McGraw-Hill, Arceivala, S.J.,1998.
3. Industrial Solid Waste Management and Landfilling practice, M. Dutta, B. P. Parida, B. K. Guha and T. R. Surkrishnan.Narosa Publishing House, New Delhi(1999).
4. Design, Construction and Monitoring of Landfills, AmalenduBagchi.John Wiley and Sons. New York. (1994).
5. Environmental Pollution Control Engineering, C. S. Rao Wiley Eastern Ltd. New Delhi (1995). .M.N.Rao & Datta, Waste Water Treatment, 3rd Edition, Oxford &IBH publishing Company Pvt Ltd.
6. Treatment of Industrial Effluent, Callegly, Forster and Stafferd, Hodder and Stonghton, 1988

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	DESIGN OF HEAT TRANSFER EQUIPMENTS				

Unit-I

DESIGN OF HEAT EXCHANGERS & CONDENSERS

Heat Exchangers-mean temperature differences for parallel and counter flow effectiveness method (NTU), Overall heat transfer co-efficient –temperature distribution and heat flow in a condenser-pressure drop in a condenser-extended fin surfaces-consideration of fouling factors- LMTD correction factor.

Unit-II

DESIGN OF EVOPORATORS: Temperature distribution and heat flow in an evaporator – pressure drop-factor to be consider in the design of heat transfer equipment – types of heat consideration of fouling factor-correction factor.

Unit-III

DESIGN OF COMPRESSORS: Types – equivalent shaft work- volume metric efficiency- factors affection total volume metric efficiency – compound compression with inter cooling – rotary compressors surging.

Unit-IV

DESIGN OF COOLING TOWERS AND SPRAY PONDS & DUCTS: Classification-performance of cooling towers-analysis of counter flow cooling towers – enthalpy – temperature diagram of air and water- cooling ponds- types of cooling ponds-cross flow cooling towers – procedure for calculation of outlet conditions, Continuity equation – Bernoull's equation – pressure losses – frictional charts – co efficient of resistance for fillings – duct sizing methods.

Unit-V

DESIGN OF FANS & PIPING SYSTEM: Standard air –fan horse power – fan efficiency – similarity laws-fan laws – performance co efficient –theoretical expressions for total pressure drop by a fan, centrifugal fan, axial flow fan – system resistance, Requirements of a good piping system- pressure drop in pipe-Moody chart refrigerant piping – discharge line- liquid line-suction line – piping arrangement

TEXT BOOK

1. Heat and Mass Transfer by - Arora and Domkundwar.

REFERENCES

1. Cooling Tower, Fundamentals- John C. Hensley, SPX Cooling Technologies
2. Heat exchangers Selection, Rating and Thermal Design – Sadik Kakac,Hongtan Liu,Anchasa Pramunjanaroenkij, CRC Press
3. Process Heat Transfer – Donald Q. Kern, Tata McGraw-Hill
4. Process Heat Transfer – Hewitt ,Shires & Bott, CRC Press
5. Heat Pipes Theory, Design & Applications – D.A. Reay, P.D.Dunn, Pergamon
6. Cooling Techniques for Electronic Equipment– Dave S. Steinberg, Wiley-InterScience Publication
7. Fundamentals of Heat Exchanger Design -Ramesh K. Shah, Dusan P. Sekulic,Wiley- India

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COMBUSTION, EMISSIONS AND ENVIRONMENT

UNIT – I :

PRINCIPLES OF COMBUSTION: Chemical composition , Flue gas analysis, dew point of products, Combustion stoichiometry, Chemical kinetics, Rate of reaction, Reaction order, Molecularity, Zeroth, first, second and third order reactions , complex reactions, chain reactions, Theories of reaction Kinetics, General oxidation behavior of HCs.

UNIT-II:

THERMODYNAMICS OF COMBUSTION: Enthalpy of formation, Heating value of fuel, Adiabatic flame Temperature, Equilibrium composition of gaseous mixtures.

UNIT-III:

LAMINAR AND TURBULENT FLAMES PROPAGATION AND STRUCTURE: Flame stability, burning velocity of fuels, Measurement of burning velocity, factors affecting the Burning velocity. Combustion of fuel droplets and sprays, Combustion systems, Pulverized fuel furnaces- fixed, entrained and fluidized bed systems.

UNIT-IV:

POLLUTION FORMATION MEASUREMENT AND CONTROL: Causes for Formation of NO_x, SO_x, CO_x, Smoke and UBHC. Different methods of measurement of pollutants. methods of controlling the formation of pollutants, BHARAT and EURO standards of emissions.

UNIT-V:

ENVIRONMENTAL CONSIDERATIONS: Air pollution, effects on environment, human health etc. Principal pollutants, Legislative measures, methods of emission control.

TEXT BOOK:

1. Fuels and combustion, Sharma and Chandra Mohan, Tata McGraw Hill, 1984..

REFERENCES:

1. Combustion Fundamentals , Roger A strehlow , McGraw Hill.
2. Combustion Engineering and Fuel Technology , Shaha A.K., Oxford and IBH.
3. Principles of Combustion , KannethK.Kuo, Wiley and Sons.
4. Combustion , Samir Sarkar , Mc. Graw Hill, 2009.
5. An Introduction to Combustion , Stephen R. Turns, Mc. Graw Hill International Edition.
6. Combustion Engineering , Gary L. Berman & Kenneth W. Ragland, Mc. Graw Hill International Edition 2009.

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GREEN BUILDINGS

UNIT-I

Green Buildings: Definition of Green Buildings, typical features of green buildings, benefits of Green Buildings- Sustainable site selection and planning of buildings to maximize comfort, day lighting, ventilation, planning for storm water drainage

UNIT- II

Environmentally friendly building materials and technologies: Natural Materials like bamboo, timber, rammed earth, stabilized mud blocks, hollow blocks, lime & lime-pozzolana cements, materials from agro and industrial waste, ferro-cement and ferro-concrete, alternative roofing systems, various paints reducing the heat gain of the building, etc.

UNIT – III

Energy and resource conservation: Need for energy conservation, various forms of energy used in buildings, embodied energy of materials, energy used in transportation and construction processes- water conservation systems in buildings-water harvesting in buildings – waste to energy management in residential complexes or gated communities.

UNIT- IV

Use of renewable energy resources:Wind and Solar Energy Harvesting, potential of solar energy in India and world, construction and operation of various solar appliances, success case studies of fully solar energy based buildings in India.

UNIT- V

Climate Design:Local climatic conditions – temperature, humidity, wind speed and direction-impact of climate change on built environment – comforts: the desirable conditions – Principles of thermal design – means of thermal –light and lighting-building acoustics- energy efficient lighting, Ventilation and air quality requirement, various techniques for passive cooling, garden roofs, case studies for passive cooling and thermal comfort.

UNIT- VI

Green Building Rating Systems: Introduction to Leadership in Energy and Environment Design (LEED), Green Rating systems for Integrated Habitat Assessment – Modular wastewater treatment systems for built environment – Building automation and building management systems.

TEXT BOOKS

1. ‘Alternative building materials and technologies’ by K.S. Jagadish, B.V. Venkatarama Reddy and K.S. Nanjunda Rao.
2. ‘Non-Conventional Energy Resources’ by G. D. Rai, Khanna Publishers.

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MODELING AND SIMULATION LAB

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VALUE EDUCATION					

UNIT I

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

UNIT II

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

UNIT III

Personality and Behavior Development - Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship.

UNIT IV

Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation. Doing best for saving nature

UNIT V

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

TEXT BOOK:

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

M.Tech - III Sem		L	T	P	C
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DESIGN AND ANALYSIS OF EXPERIMENTS					

UNIT-I
STRATEGY OF EXPERIMENTATION: Guidelines for designing experiments, sampling and sampling distributions, hypothesis testing, choice of sample size. Experiments with single factor**:** Analysis of variance, analysis of the fixed effects model, model adequacy checking, sample computer output, regression approach to the analysis of variance.

UNIT-II
FACTORIAL DESIGNS: Principles, advantage of factorials, two-factor factorial design, general factorial design, fitting response curves and surfaces.2^k factorial design: 2^2 design, 2^3 design, General 2^kdesign, single replicate of 2^k design.

UNIT-III
TWO-LEVEL FRACTIONAL FACTORIAL DESIGNS: one-half fraction of 2^K design, one-quarter fraction of 2^K design, blocking replicated 2^K factorial design, confounding in 2^K factorial design. Three-level and mixed-level factorial design: 3^K factorial design, confounding in 3^K factorial design, fractional replication of 3^K factorial design, factorials with mixed levels.

UNIT-IV
REGRESSION MODELS: Linear regression models, estimation of the parameters, hypothesis testing in multiple regression, confidence intervals in multiple regression, prediction of new response observations, regression model diagnostics.

UNIT-V
RESPONSE SURFACE METHODS: Introduction, method of steepest ascent, analysis of second-order response surface, experimental designs for fitting response surfaces.

TEXT BOOK:
1. D.C. Montgomery, "Design and Analysis of Experiments", 5th edition, John Wiley and sons, 2009.

REFERENCES:
1. D.C. Montgomery," Introduction to Statistical Quality Control", 4th edition, John Wiley and sons, 2001.
2. Angela Dean and Daniel Voss, "Design and Analysis of Experiments", Springer, 1999

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CONVECTIVTE HEAT TRANSFER

UNIT-I:
Introduction to Forced, free & combined convection – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers.

Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations.

UNIT-II:
EXTERNAL LAMINAR FORCED CONVECTION: Similarity solution for flow over an isothermal plate – integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate.

External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions – Effects of dissipation on flow over a flat plate.

Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields.

Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.

UNIT – III:
NATURAL CONVECTION: Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations.

Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.

UNIT – IV:
COMBINED CONVECTION: Governing parameters & equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows

- internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.UNIT - V:

UNIT – V:
CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA: Area weighted velocity Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers.

TEXT BOOK: 1. Convective Heat & Mass Transfer /Kays & Crawford/TMH

REFERENCE:
1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David Naylor, MGH
2.Convection Heat Transfer / Adrian Bejan / Wiley
3.Principles of Convective Heat Transfer / Kaviany, Massoud /Springer

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ADVANCED FINITE ELEMENTS METHODS					

UNIT – I

FORMULATION TECHNIQUES: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

UNIT – II

ONE-DIMENSIONAL ELEMENTS: Bar, trusses, beams and frames, displacements, stresses and temperature effects.

UNIT – III

TWO DIMENSIONAL PROBLEMS: CST, LST, four nodded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin.

UNIT – IV

ISOPARAMETRIC FORMULATION: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal’s triangle, Patch test.

UNIT – V

FINITE ELEMENTS IN STRUCTURAL ANALYSIS: Static and dynamic analysis, eigen value problems,
and their solution methods, case studies using commercial finite element packages.

TEXT BOOK:

1. Finite element methods by Chandrubatla & Belagondu.

REFERENCES:

1. J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994
2. Zienckiwicz O.C. & R. L. Taylor, Finite Element Method, McGraw-Hill,1983.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996

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MATEIALS AND DEVICES FOR ENERGY APPLICATIONS

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OPEN ELECTIVE

Students are advised to opt for an open elective course of their choice being offered by other departments of institute

(OR)

MOOCS/NPTEL Certification courses duly approved by the department

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DESERTAION PHASE – I

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DESERTAION PHASE – II