# DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH, LUCKNOW

# Syllabus

# For

# M.Tech. (Thermal Engineering)

**(Effective from the Session: 2016-17)**

# Dr. A.P.J. Abdul Kalam Technical University, Lucknow, Uttar Pradesh

## COURSE STRUCTURE AND EVALUATION SCHEME FOR
## M.TECH - THERMAL ENGINEERING
(EFFECTIVE FROM THE SESSION: 2016-17)

### Semester -I

| S. No. | Subject Code | Name of the Subject | Periods | | | Credit | Evaluation Scheme | | | | | Subject Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Theory | | | Practical | | |
| | | | L | T | P | | CT | TA | ESE | TA | ESE | |
| 1 | MTME 101 | Simulation, Modelling & Analysis | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 2 | MTTE 101 | Advanced Thermal Engineering | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 3 | MTTE 01? | Departmental Elective – I | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 4 | MTTE 02? | Departmental Elective - II | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 5 | | Research Process & Methodology | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 6 | MTME 151 | Simulation Modeling & Analysis Lab | -- | -- | 3 | 2 | -- | -- | -- | 20 | 30 | 50 |
| 7 | MTTE 151 | Advanced Thermal Engineering Lab | -- | -- | 2 | 1 | -- | -- | -- | 20 | 30 | 50 |
| | | **Total** | | | | 18 | | | | | | **600** |

| | | |
|---|---|---|
| **Departmental Elective–I** | MTTE 011 | Alternative Fuels & Engine Pollution |
| | MTTE 012 | Refrigeration & Air Conditioning |
| | MTTE 013 | Advanced Fluid Mechanics |
| | MTTE 014 | Gas Dynamics |

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|---|---|---|
| **Departmental Elective–II** | MTTE 021 | Turbo Machines |
| | MTTE 022 | Cryogenic Engineering |
| | MTTE 023 | Advanced I.C. Engines |
| | MTTE 024 | Solar Energy Technology |

## Semester –II

| S. No. | Subject Code | Name of the Subject | Periods | | | Credit | Evaluation Scheme | | | | | Subject Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | | | Practical | | |
| | | | | | | | CT | TA | ESE | TA | ESE | |
| | MTTE 201 | Advanced Heat & Mass Transfer | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 1 | MTTE 202 | Computational Fluid Dynamics | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 3 | | Departmental Elective-III | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 4 | | Departmental Elective-IV | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 5 | | Elective-V | 3 | 0 | 0 | 3 | 20 | 10 | 70 | -- | -- | 100 |
| 6 | MTTE 251 | Advanced Heat & Mass Transfer Lab | -- | -- | 3 | 2 | -- | -- | -- | 20 | 30 | 50 |
| 7 | MTTE 252 | Seminar-I | -- | -- | -- | 1 | -- | -- | -- | 50 | -- | 50 |
| | | **Total** | | | | 18 | | | | | | **600** |

| | | |
|---|---|---|
| **Departmental Elective – III** | MTME 031 | Advanced Finite Element Analysis |
| | MTTE 031 | Fuels, Combustion And Environment |
| | MTTE 032 | Energy Management |
| | MTTE 033 | Equipment Design For Thermal Systems |

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|---|---|---|
| **Departmental Elective – IV** | MTME 041 | Optimization Techniques & Design Of Experiments |
| | MTTE 041 | Experimental Techniques In Fluid Flow & Heat Transfer |
| | MTTE 042 | Convective Heat Transfer |
| | MTTE 043 | Thermal And Nuclear Power Plants |

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|---|---|---|
| **Elective – V** | MTTE 051 | Thermal Measurements and Process Controls |
| | MTTE 052 | Combustion Technology |
| | MTTE 053 | Environmental Pollution & Its Control |
| | MTTE 054 | Advanced Power Plant Engineering |

## Semester – III

| S. No. | Subject Code | Name of the Subject | Periods | | | Credit | Evaluation Scheme | | | | | Subject Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | | | Practical | | |
| | | | | | | | CT | TA | ESE | TA | ESE | |
| 1 | MTTE 352 | Seminar-II | 0 | 0 | 6 | 3 | -- | -- | -- | 100 | -- | 100 |
| 2 | MTTE 351 | Dissertation | 0 | 0 | 30 | 15 | -- | -- | -- | 200 | 300 | 500 |
| | | **Total** | | | | 18 | | | | | | **600** |

## Semester – IV

| S. No. | Subject Code | Name of the Subject | Periods | | | Credit | Evaluation Scheme | | | | | Subject Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Theory | | | Practical | | |
| | | | | | | | CT | TA | ESE | TA | ESE | |
| 1 | MTTE 451 | Dissertation (Final) | 0 | 0 | 36 | 18 | -- | -- | -- | 200 | 400 | 600 |
| | | **Total** | | | | 18 | | | | | | **600** |

## SIMULATION, MODELLING & ANALYSIS

**MTME 101** **L T P**
**3 0 0**

**Introduction:** Simulation: a tool, advantages and disadvantages of simulation, areas of application, systems and system environment, components of a system, discrete and continuous systems, discrete event system simulation.
**General Principles:** Concepts in discrete event simulation, time advance algorithm, manual simulation using event scheduling, basis properties and operations.

**Models In Simulation:** Terminology and concepts, statistical models: queuing systems; inventory systems; reliability and maintainability, limited data, discrete distributions: Bernoulli distribution; Bionomial distribution; Geometric distribution, continuous distribution: Uniform distribution; Exponential distribution; Gamma distribution; Normal distribution; Weibull distribution; Triangular Distribution; Lognormal distribution, poisson process,

**Queueing Models:** Characteristics of queuing systems, the calling population, system capacity, arrival process, service mechanism, queuing notations, long run measures of performance of queuing systems, server utilization in G/G/1/∞/∞ queues, server utilization in G/G/C/∞/∞ queues, server utilization and system performance, costs in queuing problems, Larkovian models.

**Random Number Generation:** Properties of random numbers, Pseudo random numbers, techniques of generating random numbers, tests of random numbers.
**Random Variate Generation:** Inverse transform technique, Direct transformation for the Normal and Lognormal distribution, Convolution Method, Acceptance rejection technique.

**Input Modelling And Validation:** Steps in the development of model, data collection, Distribution identification, Parameter estimation, Goodness of Fit Tests,selecting input models without data, verification and validation of simulation models.

**Books:**

1. Simulation Modelling and Analysis by Law and Kelton, Mc Graw Hill.
2. Simulation Model Design& execution by Fishwich, Prentice Hall.
3. Discrete event system simulation by Banks, Carson, Nelson and Nicol.

## ADVANCED THERMAL ENGINEERING

**MTTE 101** **L T P**
**3 0 0**

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

FINITE DIFFERENCE METHODS FOR CONDUCTION: ID & 2D 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.

Viscous Flow: Derivation of Navier-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.

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

GAS DYNAMICS: Fundamental thermodynamic concepts, isentropic conditions, mach numbers and area, Velocity relations, Dynamic Pressure, Normal shock relation for perfect gas, Supersonic flow, oblique shock waves, Normal shock recoveries, detached shocks, Aerofoil theory.

REFERENCES:

1. Basic and Applied Thermodynamics/ P.K.Nag/ TMH
2. Element of Gas Dynamics/Yahya/TMH
3. Fluid Mechanics and Machines/Modi and Seth/Standard Book House
4. Thermodynamics/Sonnatag & Van Wylen / John Wiley & Sons
5. Thermodynamics for Engineers/Doolittle-Messe / John Wiley & Sons
6. Heat Transfer/ P.K.Nag /TMH
7. Thermal Engineering / Soman / PHI
8. Thermal Engineering / Rathore / TMH
9. Engineering Thermodynamics/Chatopadyaya/

## SIMULATION, MODELLING & ANALYSIS LAB

**MTME 151** **L T P**
**0 0 3**

1. Study of simulation software Like ARENA , MATLAB.
2. Simulation of translational and rotational mechanical systems
3. Simulation of Queuing systems
4. Simulation of Manufacturing System
5. Generation of Random number
6. Modeling and Analysis of Dynamic Systems
7. Simulation mass spring damper system
8. Simulation of hydraulic and pneumatic systems.
9. Simulation of Job shop with material handling and Flexible manufacturing systems
10. Simulation of Service Operations

## ADVANCED THERMAL ENGINEERING LAB

**MTTE 151** **L T P**
**0 0 2**

1. Performance analysis of four stroke S.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance.
2. Performance analysis of four stroke C.I. Engine- Determination of indicated and brake thermal efficiency, specific fuel consumption at different loads, Energy Balance.
3. Performance analysis of an alternate fuel on computerized IC Engine test rig.
4. Calculation of thermal conductivity of metal rods.
5. Experiment on Pin fin Apparatus (free and force convection heat transfer).
6. COP calculation on air conditioning test rig apparatus.
7. COP calculation on simple vapour compression refrigeration test rig.
8. Performance test and analysis of exhaust gases of an I.C. Engine.
9. Dryness fraction estimation of steam
10. Compressibility factor measurement of different real gases.

## DEPARTMENTAL ELECTIVE-I

## ALTERNATIVE FUELS AND ENGINE POLLUTION

**MTTE 011** **L T P**
**3 0 0**

Alternative fuels, Biodiesel production & specifications, transesterification process, alcohol, emulsified fuels, DME, GTI, Introduction to gaseous alternative fuels, Hydrogen, production, storage, combustive properties of hydrogen, hydrogen induction systems, Compressed natural gas, production, supply, storage, filling systems, LPG. Pollutants due to transportation systems, Nature of pollutants and their formation, Local and global effects of pollutants, Effects of engine pollutants on human health, Photochemical smog, Emission regulations, regulated/unregulated pollutants, technologies to control engine pollution

## REFRIGERATION AND AIR CONDITIONING

**MTTE 012** **L T P**
**3 0 0**

**VAPOUR COMPRESSION REFRIGERATION:** Performance of Complete vapor compression system.
**Components of Vapor Compression System:** The condensing unit – Evaporators – Expansion valve – Refrigerants – Properties – ODP & GWP - Load balancing of vapor compression Unit.
**Compound Compression**: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.
**PRODUCTION OF LOW TEMPERATURE:** Liquefaction system ;Cascade System – Applications.– Dry ice system.
**Vapor absorption system** – Simple and modified aqua – ammonia system – Representation on Enthalpy –Concentration diagram. Lithium – Bromide system Three fluid system – HCOP.

**AIR REFRIGERATION:** Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.
**Steam Jet refrigeration system**: Representation on T-s and h-s diagrams – limitations and applications.
**Unconventional Refrigeration system** – Thermo-electric – Vortex tube & Pulse tube – working principles.

**AIR –CONDITIONING:** Psychrometric properties and processes – Construction of Psychrometric chart. Requirements of Comfort Air –conditioning – Thermodynamics of human body – Effective temperature and Comfort chart – Parameters influencing the Effective

Temperature. Summer , Winter and year round air – conditioning systems. Cooling load Estimation: Occupants, equipments, infiltration, duet heat gain fan load, Fresh air load.

**AIR –CONDITIONING SYSTEMS:** All Fresh air , Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP,RSHF, ESHF and GSHF for different systems. **Components:**Humidification and dehumidification equipment – Systems of Air cleaning – Grills and diffusers – Fans and blowers – Measurement and control of Temperature and Humidity.

**REFERENCES:**


1. Refrigeration & Air Conditioning /C.P. Arora/TMH
2. Refrigeration & Air Conditioning /Arora & Domkundwar/ Dhanpat Rai
3. Refrigeration and Air Conditioning /Manohar Prasad/
4. Refrigeration and Air Conditioning /Stoecker /Mc Graw Hill
5. Principles of Refrigeration/Dossat /Pearson
6. Refrigeration and Air Conditioning /Ananthanarayana /TMH
7. Refrigeration and Air Conditioning /Jordan& Preister /Prentice Hall
8. Refrigeration and Air Conditioning/Dossat /Mc Graw Hill


## ADVANCED FLUID MECHANICS

**MTTE 013** **L T P**
**3 0 0**

**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 Cartesystems normal and tangential accelerations, Euler's, Bernouli equations in 3D– Continuity and Momentum Equations.

**Viscous Flow:** Derivation of Navier-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.

**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.

**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 – kepsilon model - boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders
**Internal Flow**: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth rough Pipes – Roughness of Commercial Pipes – Moody's diagram.

**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.

**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 and Machines/CP Kodandaraman/New Age Publications
6. A Text book of Fluid Mechanics/RK Rajput/S. Chand
7. Boundary Layer Theory/ Schlichting H /Springer Publications
8. Dynamics & Theory and Dynamics of Compressible Fluid Flow/ Shapiro.
9. Fluid Mechanics and Machinery/ D. Rama Durgaiah/New Age Publications
10. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH

## GAS DYNAMICS

**MTTE 014** **L T P**
**3 0 0**

**SENTROPIC FLOWS**
Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts – Nozzle and Diffusers

**FLOW THROUGH DUCTS**
Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties.

**NORMAL AND OBLIQUE SHOCKS**
Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl – Meyer relations – Applications.

**JET PROPULSION**
Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines.

**SPACE PROPULSION** Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights.

**TEXTBOOKS:**
1. Anderson, J.D., "Modern Compressible flow", 3rd Edition, McGraw Hill, 2003.
2. Yahya, S.M. "Fundamentals of Compressible Flow", New Age International (P) Limited, New Delhi, 1996.

## DEPARTMENTAL ELECTIVE-II

## TURBO MACHINES

**MTTE 021** **L T P**
**3 0 0**

**FUNDAMENTALS OF TURBO MACHINES**: Classifications, Applications, Thermodynamic analysis, Isentropic flow. Energy transfer. Efficiencies, Static and Stagnation conditions, Continuity equations, Euler's flow through variable cross sectional areas, Unsteady flow in turbo machines

**STEAM NOZZLES**: Convergent and Convergent-Divergent nozzles, Energy Balance, Effect of back pressure of analysis. Designs of nozzles.

**Steam Turbines**: Impulse turbines, Compounding, Work done and Velocity triangle, Efficiencies, Constant reactions, Blading, Design of blade passages, Angle and height, Secondary flow. Leakage losses, Thermodynamic analysis of steam turbines.

**GAS DYNAMICS**: Fundamental thermodynamic concepts, isentropic conditions, mach numbers and area, Velocity relations, Dynamic Pressure, Normal shock relation for perfect gas. Super sonic flow, oblique shock waves. Normal shock recoveries, Detached shocks, Aerofoil theory.
**Centrifugal compressor**: Types, Velocity triangles and efficiencies, Blade passage design, Diffuserand pressure recovery. Slip factor, Stanitz and Stodolas formula's, Effect of inlet mach numbers, Pre whirl, Performance.

**AXIAL FLOW COMPRESSORS**: Flow Analysis, Work and velocity triangles, Efficiencies, Thermodynamic analysis. Stage pressure rise, Drgree of reaction, Stage Loading, General design, Effect of velocity, Incidence, Performance.

**Cascade Analysis**: Geometrical and terminology. Blade force, Efficiencies, Losses, Free end force, Vortex Blades.

**AXIAL FLOW GAS TURBINES**: Work done. Velocity triangle and efficiencies, Thermodynamic flow analysis, Degree of reaction, Zweifels relation, Design cascade analysis, Soderberg, Hawthrone, Ainley, Correlations, Secondary flow, Free vortex blade, Blade angles for variable degree of reaction. Actuator disc, Theory, Stress in blades, Blade assembling, Material and cooling of blades, Performances, Matching of compressors and turbines, Off design performance.

**REFERENCES:**
1. Principles of Turbo Machines/DG Shepherd / Macmillan
2. Fundamentals of Turbomachinery/William W Perg/John Wiley & Sons
3. Element of Gas Dynamics/Yahya/TMH
4. Principles of Jet Propulsion and Gas Turbine/NJ Zucrow/John Wiley & Sons/Newyork
5. Turbines, Pumps, Compressors/Yahya/TMH
**6.** Practice on Turbo Machines/ G.Gopal Krishnan & D.Prithviraj/ Sci Tech Publishers, Chennai
7. Theory and practice of Steam Turbines/ WJ Kearton/ELBS Pitman/London
8. Gas Turbines Theory and Practice/Zucrow/John Wiley & Sons/Newyork
9. Element of Gas Dynamics/Liepeman and Roshkow/ Dover Publications

## CRYOGENIC ENGINEERING

**MTTE 022** **L T P**
**3 0 0**

**INTRODUCTION TO CRYOGENIC SYSTEMS:** Mechanical Properties at low temperatures. Properties of Cryogenic Fluids.

**Gas Liquefaction:** Minimum work for liquefaction. Methods to protect low temperature. Liquefaction systems for gages other than Neon. Hydrogen and Helium.

**LIQUEFACTION SYSTEMS FOR NEON, HYDROGEN AND HELIUM:** Components of Liquefaction systems. Heat exchangers. Compressors and expanders. Expansion valve, Losses in real machines.

**GAS SEPARATION AND PURIFICATION SYSTEMS:** Properties of mixtures, Principles of mixtures, Principles of gas separation, Air separation systems.

**CRYOGENIC REFRIGERATION SYSTEMS:** Working Medium, Solids, Liquids, Gases, Cryogenic fluid storage & transfer, Cryogenic storage systems, Insulation, Fluid transfer mechanisms, Cryostat, Cryo Coolers.

**APPLICATIONS:** Space technology, In-Flight air separation and collection of LOX, Gas industry, Biology, Medicine, Electronics.

**REFERENCES:**
1. Cryogenic Systems/ R.F.Barren/ Oxford University Press
2. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
3. Cryogenic Heat Transfer/ R.F.Baron
4. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 1986
5. Cryogenic Engineering/ R.B.Scottm Vin Nostrand/ Inc. New Jersey, 1959
6. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1968
7. Cryogenic Process Engineering/ K.D. Timmerhaus & TM Flynn/ Plenum Press, 1998
8. Hand Book of Cryogenic Engineering – J.G.Weisend –II, Taylor and Francis, 1998

## ADVANCED I.C. ENGINES

**MTTE 023** **L T P**
**3 0 0**

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

**GAS EXCHANGE PROCESSES:** Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging.

**Charge Motion**: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows.

**ENGINE COMBUSTION IN S.I ENGINES:** Combustion and Speed – Cyclic Variations – Ignition –Abnormal combustion Fuel factors, MPFI, SI engine testing.

**COMBUSTION IN CI ENGINES**: Essential Features – Types off Cycle. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

**POLLUTANT FORMATION AND CONTROL:** Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, unburnt Hydrocarbon and particulate – Emissions – Measurement – Exhaust Gas Treatment, Catalytic converter, SCR, Particulate Traps, Lean, NOx, Catalysts.

**ENGINE HEAT TRANSFER:** Importance of heat transfer, heat transfer and engine energy balance, Convective heat transfer , radiation heat transfer, Engine operating characteristics. Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen.

**MODERN TRENDS IN IC ENGINES:** Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts.

**REFERENCES:**


1. I.C. Engines / V.Ganesan/TMH
2. I.C. Engines Fundamentals/Heywood/TMH
3. I.C. Engines/G.K. Pathak & DK Chevan/ Standerd Publications
4. I.C. Engines /RK Rajput/Laxmi Publications
5. Computer Simulation of C.I. Engine Process/ V.Ganesan/University Press
6. Fundamentals of IC Engines/HN Gupta/PHI/2nd edition
7. I.C. Engines/Fergnson/Wiley
8. The I.C. Engine in theory and Practice Vol.I / Teylor / IT Prof. And Vol.II

## SOLAR ENERGY TECHNOLOGY

**MTTE 024** **L T P**
**3 0 0**

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 collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors – cylindrical parabolic collectors – Orientation and tracking – Performance Analysis.

**DESIGN OF SOLAR WATER HEATING SYSTEM AND LAYOUT:** Power generation – solar central receiver system – Heliostats and Receiver – Heat transport system – solar distributed receiver system – Power cycles, working fluids and prime movers, concentration ratio.

**THERMAL ENERGY STORAGE:** Introduction – Need for – Methods of sensible heat storage using solids and liquids – Packed bed storage – Latent heat storage – working principle – construction – application and limitations. Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

**DIRECT ENERGY CONVERSION:** solid-state principles – semiconductors – solar cells – performance – modular construction – applications. conversion efficiencies calculations.

**ECONOMICS:** Principles of Economic Analysis – Discounted cash flow – Solar system – life cycle costs – cost benefit analysis and optimization – cost based analysis of water heating and photo voltaic applications.

**REFERENCES:**

1. Principles of solar engineering/ Kreith and Kerider/Taylor and Franscis/2nd edition
2. Solar energy thermal processes/ Duffie and Beckman/John Wiley & Sons
3. Solar energy: Principles of Thermal Collection and Storage/ Sukhatme/TMH/2nd edition
4. Solar energy/ Garg/TMH
5. Solar energy/ Magal/Mc Graw Hill
6. Solar Thermal Engineering Systems / Tiwari and Suneja/Narosa
7. Power plant Technology/ El Wakil/TMH

## ADVANCED HEAT & MASS TRANSFER

**MTTE 201** **L T P**
**3 0 0**

**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.

**FINITE DIFFERENCE METHODS FOR CONDUCTION**: ID & 2D 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.

**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.

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

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

**REFERENCES:**


1. Principals of Heat Transfer/Frank Kreith/Cengage Learning
2. Elements of Heat Transfer/E. Radha Krishna/CRC Press/2012
3. Heat Transfer/RK Rajput/S.Chand
4. Introduction to Heat Transfer/SK Som/PHI
5. Engineering Heat & Mass Transfer/Mahesh Rathore/Lakshmi Publications
6. Heat Transfer / Necati Ozisik / TMH
7. Heat Transfer / Nellis & Klein / Cambridge University Press / 2012.
8. Heat Transfer/ P.S. Ghoshdastidar/ Oxford Press
9. Engg. Heat & Mass Transfer/ Sarit K. Das/Dhanpat Rai

## COMPUTATIONAL FLUID DYNAMICS

**MTTE 202** **L T P**
**3 0 0**

**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.

**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.

**FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOW**S: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.
Treatment of compressible flows: potential equation, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

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

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

**REFERENCES:**


1. Computational fluid dynamics/ T. J.C'hung/ Cambridge University press,2002.
2. Text book of fluid dynamics/ **Frank** Choriton/ CBS Publishers & distributors, 1985
3. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.
4. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
5. Computational Fluid Dynamics: Basics with applications/John D. Anderson/ Mc Graw Hill.
6. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
7. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition

## LAB-III

## ADVANCED HEAT & MASS TRANSFER LAB

**MTTE 251** **L T P**
**0 0 3**

**List of Experiments:**

1. Determination of Steffan Boltzman Constant.
2. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers
3. Experiments on Boiling of Liquid and Condensation of Vapour
4. Experiment on Transient Conduction Heat Transfer
5. Determination of Thermal Conductivity of a Metal Rod.
6. Determination of Overall Heat Transfer Coefficient of a Composite wall.
7. Determination of Effectiveness on a Metallic fin.
8. Determination of Heat Transfer Coefficient in a free Convection on a vertical tube.
9. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe.
10. Determination of Emissivity of a Surface.

## DEPARTMENTAL ELECTIVE – III
## ADVANCED FINITE ELEMENT ANALYSIS

**MEM 031** **L T P**
**3 0 0**

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin's Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain-displacement relations.

**1 -D STRUCTURAL PROBLEMS**: Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems.

**ANALYSIS OF TRUSSES** : Plane Trusses and Space Truss elements and problems **ANALYSIS OF BEAMS** : Hermite shape functions – stiffness matrix – Load vector – Problems.

**2-D PROBLEMS:** CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration. Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements.

**3-D PROBLEMS**: Tetrahedran element – Jacobian matrix – Stiffness matrix.

**SCALAR FIELD PROBLEMS**: 1 -D Heat conduction-Slabs – fins - 2-D heat conduction problems –Introduction to Torsional problems.

Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

**REFERENCES:**


1. The Finite Element Methods in Engineering / SS Rao / Pergamon.
2. Finite Element Methods: Basic Concepts and applications, Alavala, PHI
3. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice –Hall
4. Finite Element Method – Zincowitz / Mc Graw Hill
5. Introduction to Fininte element analysis- S.Md.Jalaludeen,Anuradha Publications, print-2012
6. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition
7. Finite Element Method – Krishna Murthy / TMH
8. Finite Element Analysis – Bathe / PHI

## FUELS, COMBUSTION AND ENVIRONMENT

**MTTE 031** **L T P**
**3 0 0**

**FUELS:** Detailed classification – Conventional and Unconventional Solid, Liquid, gaseous fuels and nuclear fuels – Origin of Coal – Analysis of coal. Coal – Carborisation, Gasification and liquification – Lignite: petroleum based fuels – problems associated with very low calorific value gases: Coal Gas – Blast Furnace Gas Alcohols and Biogas.

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

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

**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 Fluidised Bed Systems.

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

**REFERENCES:**


1. Combustion Fundamentals / Roger A strehlow / Mc Graw Hill
2. Fuels and combustion / Sharma and Chander Mohan/ Tata Mc Graw Hill
3. Combustion Engineering and Fuel Technology / Shaha A.K./ Oxford and IBH.
4. Principles of Combustion / Kanneth K.Kuo/ Wiley and Sons.
5. Combustion / Sarkar / Mc. Graw Hill.
6. An Introduction to Combustion / Stephen R. Turns/ Mc. Graw Hill International Edition.
7. Combustion Engineering / Gary L. Berman & Kenneth W. Ragland/ Mc. Graw Hill International Edition.

## ENERGY MANAGEMENT

**MTTE 032** **L T P**
**3 0 0**

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

**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.

**ECONOMIC ANALYSIS**: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

**METHODS OF EVALUATION OF PROJECTS**: Payback, Annualized costs, Investor's rate of return, Present worth, Internal rate of return, Pros and cons of the common method of analysis, Replacement analysis.

**ALTERNATIVE ENERGY SOURCES: SOLAR ENERGY**: Types of devices for solar energy collections, Thermal storage system, Control systems. Wind Energy, Availability, Wind Devices, Wind Characteristics, performance of turbines and systems.

**REFERENCES:**

1. Energy Management Hand Book / W.C. Turner (Ed)
2. Energy Management Principles / CB Smith/ Pergamon Press
3. Energy Management / W.R.Murthy and G.Mc.Kay / BS Publication
4. Management / H.Koontz and Cyrill Donnel / McGraw Hill
5. Financial Management / S.C.Kuchhal / Chaitanya Publishing House

## EQUIPMENT DESIGN FOR THERMAL SYSTEMS

**MTTE 033** **L T P**
**3 0 0**

**CLASSIFICATION OF HEAT EXCHANGERS**: Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin.

**Basic Design Methods of Heat Exchanger**: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations:

**DOUBLE PIPE HEAT EXCHANGER**: Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements. Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1 -2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1 -2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers.

**CONDENSATION OF SINGLE VAPOURS**: Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.

**VAPORIZERS, EVAPORATORS AND REBOILERS**: Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.

**DIRECT CONTACT HEAT EXCHANGER**: Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

**REFERENCES:**

1. Process Heat Transfer/D.Q.Kern/ TMH
2. Heat Exchanger Design/ A.P.Fraas and M.N.Ozisicj/ John Wiely & sons, New York.
3. Cooling Towers / J.D.Gurney and I.A. Cotter/ Maclaren

## DEPARTMENTAL ELECTIVE-IV

## OPTIMIZATION TECHNIQUES & DESIGN OF EXPERIMENTS

**MTME 041** **L T P**
**3 0 0**

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

**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.

**GEOMETRIC PROGRAMMING:** Polynomials – arithmetic – geometric inequality – unconstrained G.P – constrained G.P

**DYNAMIC PROGRAMMING:** Multistage decision process, principles of optimality, examples, conversion of final problem to an initial value problem, application of dynamic programming, production inventory. Allocation, scheduling replacement.

**LINEAR PROGRAMMING**: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints. **Simulation**: Introduction – Types – Steps – application – inventory – queuing – thermal system.

**INTEGER PROGRAMMING**: Introduction – formulation – Gomory cutting plane algorithm – Zero or one algorithm, branch and bound method.

**STOCHASTIC PROGRAMMING:** Basic concepts of probability theory, random variables – distributions – mean, variance, Correlation, co variance, joint probability distribution – stochastic linear, dynamic programming.

**REFERENCES:**


1. Optimization theory & Applications/ S.S Rao/ New Age International
2. Introductory to operation research/Kasan & Kumar/Springar
3. Optimization Techniques theory and practice / M.C Joshi, K.M Moudgalya/ Narosa Publications.
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R.L Rardin
6. Optimization Techniques/Benugundu & Chandraputla/Person Asia
7. Optimization Techniques /Benugundu & Chandraputla / Pearson Asia

## EXPERIMENTAL TECHNIQUES IN FLUID FLOW & HEAT TRANSFER

**MTTE 041** **L T P**
**3 0 0**

**WHAT DO WE MEASURE, AND WHY:** Introduction, the need for flow measurements, what do we need to know?, examples of fluid mechanics measurements, measurement of sediment load in a stream, wind-tunnel studies, propeller vibration, aeroacoustics, turbulent mixing layer, summery, outline of the theory of fluid mechanics, inviscid flow, viscous flow and turbulence, spatial and temporal resolution in measurements, correlation of data and signal analysis, classification of deterministic data, random data and signal analysis.

**PHYSICAL LAWS OF FLUID MECHANICS AND THEIR APPLICATION TO MEASUREMENT TECHNIQUES:** Introduction, similarity analysis, inviscid, incompressible fluids, inviscid, compressible fluids, viscous fluids.

**DIFFERENTIAL PRESSURE MEASUREMENT:** Introduction, uses of differential pressure measurements, principles involved in measuring velocities with differential pressure, pitot-static and impact pressure tubes, multidimensional mean-velocity measurement, physical errors in the measurement of steady pressure, types of transducers for measuring unsteady pressure, condenser microphones, Piezoelectric transducers, strain-gage transducers, mechanical transduction of time-varying press sure signals, physical errors in the measurement of unsteady pressures, spatial -resolution errors, aerodynamic interference, acoustic reflection, special techniques with microphone arrays.

**THERMAL ANEMOMETERS:**Introduction, strengths, limitations, and comparisons with laser velocimeters, hot wire sensors, probe supports and mounting, control circuit, calibration of a hot-wire anemometer, heat transfer from fine wires, high speed flow, conduction to walls, conduction to the supports, angle sensitivity and support interference, measuring mean velocity, velocity components, and temperature, one component using a single hot wire, two components using an X probe, three components, multipositiion measurements, nonisothermal flows, dynamics of the constant temperature hot-wire anemometer, frequency response of a constant temperature hot wire anemometer, optimization and electronic testing of the dynamics of the hot wire anemometer, large velocity fluctuations, dynamic effects of conduction losses to the supports, attenuation of heat waves across the thermal boundary layer of the sensor, finite resolution due to finite sensor size, noise in constant temperature thermal anemometry, film sensors, cylindrical film sensors,noncylindrical film sensors, constant current operation, other measurement techniques and applications using the constant temperature anemometer, aspirating probe, pressure measurements, total flow, split film sensors, conclusion.

**LASER VELOCIMETRY:** Introduction, basic principles, doppler shift of light scattered by small particles, optical heterodyne detection, basic optical systems, the dual beam LDV, practical dual-beam optics, characteristics of the dual-beam signal, the reference beam LDV, multivelocity

component systems, photodetectors, detector characteristics, photoemission statistics, shot noise signal to noise ratio effects, scatters particles, properties of the random light flux, signal representation random doppler light flux, statistical properties of g (x, t, D), correlation and power spectrum, burst density, high burst density signals ( N 1 ), signal processors, amplitude correlators, photon correlators, spectrum analysis, frequency trackers, frequency counters, selection of signal processors, data process, processing data from time-averaging processors, processing data from time-resolving signal processors, fringe biasing.

**VOLUME FLOW MEASUREMENTS:** Introduction, classification of metering devices, selected meter performance characteristics, orifice meters, venturi tubes and flow nozzles, elbow meters, pitot tubes, laminar flow meters, turbine meters, rotameters, target meters, thermal flowmeters, weirs and flumes, magnetic flowmeters, acoustic flowmeters, vortex-shedding meters, laser flowmeters, coriolis-acceleration flowmeters, flow conditioning devices, proving-primary and secondary standards, liquid flow; static weighing procedure, liquid flow; dynamic weighing procedure, gas flow: static gas flow: dynamic procedure, ballistic calibrators. NBS facilities and secondary standards, traceability to National flow standards-measurement assurance programs for flow, static traceability, dynamic traceability, measurement assurance programs, the role of flow conditioning in the Artifact package, test program, data analysis.

**BOOKS RECOMMENDED**

1. Aerodynamic Measurement -MIT Press -Edited by R.C.Din
2. Fluid Mechanics Measurement -Edidted by R.J.Goldstein Hemisphere Pub.Corporation

## CONVECTIVE HEAT TRANSFER

**MTTE 042** **L T P**
**3 0 0**

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.

**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.

**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.

**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.

**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.

**REFERENCES:**

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David Naylor/McGraw Hill
2. Convective Heat & Mass Transfer /Kays & Crawford/TMH

## THERMAL AND NUCLEAR POWER PLANTS

**MTTE 043** **L T P**
**3 0 0**

**INTRODUCTION**: Sources of energy, Type of Power plants. Direct energy conversion system, Energy sources in India, Recent developments in power generation, Combustion of coal, Volumetric analysis, Gravimetric analysis. Fuel gas analysis.

**Steam power plant**: Introduction. General layout of steam power plant, Modern coal. Fired Steam, Steam power plant. Power plant cycle, Fuel Handling, Combustion equipment, Ash handling, Dust collectors.

**Steam Generators**: Types, Accessories. Feed water heaters, Performance of boiling, Water treatment, Cooling towers. Steam turbines. Compounding of turbines, Steam condensers, Jet and surface condensers.

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

**NUCLEAR POWER PLANT**: Nuclear physics, Nuclear Reactor, Classification, Types of reactors, Site selection. Method of enriching uranium. Application of nuclear power plant. Nuclear Power Plant Safety: Bi-Product of nuclear power generation, Economics of nuclear power plant, Nuclear power plant in India, Future of nuclear power.

**ECONOMICS OF POWER GENERATION**: Factors affecting the economics, Loading factors, Utilization factor, Performance and operating characteristics of power plant, Point economic load sharing, Depreciation. Energy rate, Criteria for optimum loading. Specific economic energy problem.

**POWER PLANT INSTRUMENTATIONS**: Classification, Pressure measuring instrument, Temperature measurement and Flow Measurement, Analysis of combustion gases, Pollution types, Methods of control.

**REFERENCES:**

1. Power Plant Engineering / P.K.Naga / TMH
2. Power Plant Engineering / R.K.Rajput/ Lakshmi Publications.
**3.** Power Plant Engineering / P.C.Sharma/ Kotearia Publications.
4. Power Plant Technology / Wakil.

## ELECTIVE-V

## THERMAL MEASUREMENTS AND PROCESS CONTROLS

**MTTE 051** **L T P**
**3 0 0**

**GENERAL CONCEPTS**: Fundamental elements of a measuring instrument. 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 measuring – Measurement of low pressure, Manometers, Calibration methods, Dynamic characteristics- design principles.

**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.

**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.

**Level Measurement:** Direct & indirect methods, manometric methods, float level meters, electrical conductivity, Capacitive, Ultrasonic, and Nucleonic Methods. Measurement of density – Hydrometer, continuous weight method, Gamma rays, Gas impulse wheel. Velocity Measurement – Coefficient of viscosity, Ostesld method, free fall of piston under gravity, torque method. Measurement of moisture content and humidity. Measurement of thermal conductivity of solids, liquids and gases.

**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.

**REFERENCES:**

1. Measurement System, Application & Design – E.O. Doeblin.
2. Mechanical and Industrial Measurements – R.K. Jain – Khanna Publishers.
3. Mechanical Measurements – Buck & Beckwith – Pearson.
4. Control Systems, Principles & Design, 2nd Edition – M. Gopal – TMH

## COMBUSTION TECHNOLOGY

**MTTE 052** **L T P**
**3 0 0**

Introduction, Heat of reaction and formation, Adiabatic flame temperature, Chemical equilibrium, Properties of equilibrium, Combustion products of air-fuel mixtures, Chemical kinetics, reaction rates, Law of mass action, Reaction order, Activation energy, Flammability limits, SIT, Features of SI engines combustion processes, Burned and unburned mixture states, Features of CI engine combustion process, Spray structure, atomization, penetration, drop size distribution, evaporation, Ignition delay, Factors affecting delay, Mixing controlled combustion, Engine design variables and heat release rates, Vehicle emissions, Photochemical smog, Formation of NO and NO2 in SI & CI engines, Formation of CO2, Unburned HC, Flame quenching, Sources of HC in SI, Oxidation and emission, HC in CI engines, PM composition & Structure, Formation, growth, oxidation, adsorption & condensation. Emission regulations, regulated/unregulated pollutants, Effects of pollutants on human health, Introduction to EGR, EGR system classification, After treatment technologies, TWC, NOx, adsorber, selective catalytic reduction, formation of particulate matter, Diesel particulate filters, regeneration Measurement & test procedures, Exhaust smoke opacity meters, Bosch smoke meter, NDIR, FID, Chemiluminiescence detector, particulate matter measurement, IS codes for engine testing and pollution measurements. Introduction to MPFI, Gasoline direct injection, Key technical features, HCCI combustion. Lubricating oils, properties, additives, engine friction & wear, lubricating oil tribology

Books:

1. Fundamentals of Combustion DP Mishra Prentice Hall of India

## ENVIRONMENTAL POLLUTION & ITS CONTROL

**MTTE 053** **L T P**
**3 0 0**

**Introduction**: Nature and extent of pollution problems; Types of pollution. Air Pollution: General nature of air pollution; Air pollutants; Sources of air pollutants; Pollination from stationary sources and its control; Pollution from mobile sources and its control.

**Thermal Pollution**: Introduction; Effects of thermal pollution on ecology; Thermal plume, regions of plume; Parameters relevant to thermal plume and their limits; Mechanics of condenser water discharge from thermal power plants; Modelling of heated water discharge. Global Atmospheric Change: Introduction; Simple global temperature models; Green House effects, Green house gases; CO2 and its estimates; Equilibrium temperature increase caused by CO2, Chloroform carbons and warming and Ozone depletion impacts of CFC's, changes in stratospheric ozone.

Books:

1. Environmental Pollution And Protection Garg, Bansal, Tiwana Deep and Deep Publs.
2. Environmental Pollution- Hazards And Control R D Gupta Concept Publishing Company
3. Environmental Pollution Compliance H.C. Sharma CBS Publishers
4. Global Effects of Environmental Pollution American Association For The Advancemen luwer Aca

## ADVANCED POWER PLANT ENGINEERING

**MTTE 054** **L T P**
**3 0 0**

**INTRODUCTION TO POWER PLANTS AND BOILERS;** Layout of Steam, Hydel, Diesel, MHD, Nuclear and Gas turbine Power Plants Combined Power cycles – comparison and selection, Load duration Curves Steam boilers and cycles – High pressure and Super Critical Boilers – Fluidised Bed Boilers.

**STEAM POWER PLANT**: Fuel and ash handling ,Combustion Equipment for burning coal, Mechanical Stokers. Pulveriser, Electrostatic Precipitator, Draught- Different Types, Surface condenser types, cooling Towers.

**NUCLEAR AND HYDEL POWER PLANTS** : Nuclear Energy-Fission , Fusion Reaction, Types of Reactors, Pressurized water reactor ,Boiling water reactor, Waste disposal and safety Hydel Power plant- Essential elements, Selection of turbines, governing of Turbines- Micro hydel developments.

**DIESEL AND GAS TURBINE POWER PLANT:** Types of diesel plants, components , Selection of Engine type, applications-Gas turbine power plant- Fuels- Gas turbine material – open and closed cycles- reheating – Regeneration and intercooling – combines cycle.

**OTHER POWER PLANTS AND ECONOMICS OF POWER PLANTS;** Geo thermal- OTEC- tidel- Pumped storage –Solar central receiver system Cost of electric Energy- Fixed and operating costs-Energy rates- Types tariffs- Economics of load sharing, comparison of various power plants.

TEXT BOOKS:


1. Arora S.C and Domkundwar S, “A Course in Power Plant Engineering”, Dhanpat Rai, 2001.
2. Nag P.K ,”Power Plant Engineering”. Third edition Tata McGraw- Hill , 2007.