SEMESTER – 1

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

MTME 102 **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 104 **L T P**

0 0 2

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 105 **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 111 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 112 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 113 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 cylin ders **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

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MTTE 114 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 121 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 122 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 123 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 124 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