# Course Structure and Syllabus

## I Year - I Semester

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<th>S.No.</th>
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## I Year - II Semester

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## II Year - I Semester

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year - I Sem. M.Tech (Thermal Engg.)

ADVANCED OPTIMIZATION TECHNIQUES AND APPLICATIONS

UNIT - I

UNIT - II

UNIT - III
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.

UNIT - IV
LINEAR PROGRAMMING: Formulation – Sensitivity analysis. Change in the constraints, cost coefficients, coefficients of the constraints, addition and deletion of variable, constraints.

UNIT - V
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
4. Operation Research/H.A. Taha/TMH
5. Optimization in operations research/R.L Rardin
6. Optimization Techniques/Benuguni & Chandraputla/Pearson Asia
7. Optimization Techniques /Benuguni & Chandraputla / Pearson Asia
ADVANCED THERMODYNAMICS

UNIT -I:
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

UNIT-II:

UNIT-III:

UNIT-IV:

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

REFERENCES:
1. Basic and Applied Thermodynamics/ P.K.Nag/ TMH
2. Thermodynamics/Holman/ Me Graw Hill.
3. Engg. Thermodynamics/PL.Dhar / Elsevier
4. Thermodynamics/Sonnatag & Van Wylen / John Wiley & Sons
5. Thermodynamics for Engineers/Doolittle-Messe / John Wiley & Sons
6. Irreversible thermodynamics/HR De Groff.
7. Thermal Engineering / Soman / PHI
8. Thermal Engineering / Rathore / TMH
9. Engineering Thermodynamics/Chatopadyaya/
ADVANCED HEAT AND MASS TRANSFER

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

UNIT- II:
FINITE DIFFERENCE METHODS FOR CONDUCTION: ID & 2D steady state and simple transient heat conduction problems-implicit and explicit methods.

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-boussinesque approximation-different geometries-combined free and forced convection.

UNIT-V:
RADIATION HEAT TRANSFER: Radiant heat exchange in grey, non-grey bodies, with transmitting. Reflecting and absorbing media, specular surfaces, gas radiation-radiation from flames.
Mass Transfer: Concepts of mass transfer-diffusion & convective mass transfer analogies-significance of non-dimensional numbers.

REFERENCES:
1. Principals of Heat Transfer/Frank Kreith/Cengage Learning
3. Heat Transfer/FK 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
UNIT I:
INVISCID FLOW OF INCOMPRESSIBLE FLUIDS: Lagrangian and Eulerian 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 Cartesian systems normal and tangential accelerations, Euler’s, Bernoulli equations in 3D – Continuity and Momentum Equations

UNIT II:
Viscous Flow: Derivation of Navier-Stoke’s Equations for viscous compressible flow – Exact solutions to certain simple cases : Plain Poisouille flow - Couette flow with and without pressure gradient - Hagen Poisouille 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:


UNIT V:


REFERENCES:
1. Fluid Mechanics and Machines/Modi and Seth/Standard Book House
3. Fluid Mechanics/Potter/Cengage Learning
5. Fluid Mechanics and Machines/CP Kodandaraman/New Age Publications
10. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year - I Sem. M.Tech (Thermal Engg.)

TURBO MACHINES
(ELECTIVE-I)

UNIT-I:

UNIT-II:

UNIT-III:
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

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

UNIT-V:

REFERENCES:
1. Principles of Turbo Machines/DG Shepherd / Macmillian
2. Fundamentals of Turbomachinery/William W Perg/John Wiley & Sons
3. Element of Gas Dynamics/Yahya/TMH
5. Turbines, Pumps, Compressors/Yahya/TMH
7. Theory and practice of Steam Turbines/ WJ Kearton/ELBS Pitman/London
UNIT I:
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 gases other than Neon, Hydrogen and Helium.

UNIT II:

UNIT III:

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

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

REFERENCES:
2. Cryogenic Research and Applications: Marshal Sitting/ Von Nostrand/ Inc. New Jersey
3. Cryogenic Heat Transfer/ R.F. Baron
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year -I Sem. M.Tech (Thermal Engg.)

SOLAR ENERGY TECHNOLOGY
(ELECTIVE-I)

UNIT - I

UNIT - II
DESIGN OF SOLAR WATER HEATING SYSTEM AND LAYOUT

UNIT - III
Other solar devices – stills, air heaters, dryers, Solar Ponds & Solar Refrigeration, active and passive heating systems.

UNIT - IV

UNIT - V

REFERENCES:
2. Solar energy thermal processes/ Duffie and Beckman/John Wiley & Sons
4. Solar energy/ Garg/TMH
5. Solar energy/ Magal/Mc Graw Hill
7. Power plant Technology/ El Wakil/TMH
ADVANCED I.C. ENGINES
(ELECTIVE-II)


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

UNIT - III:
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.

UNIT - IV:

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

REFERENCES:
1. I.C. Engines /V. Ganesan/TMH
2. I.C. Engines Fundamentals/Heywood/TMH
4. I.C. Engines /RK Rajput/Laxmi Publications
7. I.C. Engines/Fergenson/Wiley
8. The I.C. Engine in theory and Practice Vol.I / Teylor / IT Prof. And Vol.II
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year - I Sem. M.Tech (Thermal Engg.)

NON CONVENTIONAL ENERGY RESOURCES
(ELECTIVE-II)

UNIT-I
Introduction, Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources.


UNIT-II

UNIT-III

Hydrogen Gas as Fuel: Production methods, Properties, I.C. Engines applications, Utilization strategy, Performances.

UNIT-IV
BIO-ENERGY: Biomass energy sources, Plant productivity, Biomass wastes, aerovic and Anaerobic biocconversion processed, Raw metrical and properties of bio-gas, Bio-gas plant technology and status, the energetics and economics of biomass systems, Biomass gasification

UNIT-V
WIND ENERGY: Wind, Beaufort number, Characteristics, Wind energy conversion systems, Types, Betz model, Interference factor, Power coefficient, Torque coefficient and Thrust coefficient, Lift machines and Drag machines, Matching, Electricity generation.


REFERENCES:
UNIT – I:
ATOMIC AND IONIC ARRANGEMENTS:
Amorphous Materials: Principles and Technological Applications, Lattice, Unit cell, Basis, and Crystal Structures, Points, Directions, and Planes in the unit cell, Crystal Structures of Ionic Materials
Implementation in the Atomic and Ionic Arrangements:
Points Defects, Dislocations, Significance of Dislocations, Scmid's Law, Surface defects

UNIT – II:
MECHANICAL PROPERTIES: FUNDAMENTALS AND TENSILE, HARDNESS, AND IMPACT TESTING:
The Tensile Test: Use of the Stress – Strain Diagram, True Stress and True Strain, The Bend Test for Brittle Materials, Hardness of Materials, Strain Rate effects and Impact Behaviour
Heat Treatment of Steels and Cast Irons: Designations and Classification of Steels, Simple Heat treatments, Isothermal Heat treatments, Quench and Temper Heat treatments, Surface treatments, Weldability of Steel.

UNIT – III:
FRACTURE MECHANICS, FATIGUE, AND CREEP BEHAVIOUR:

UNIT – IV:
POLYMERS:
Classifications of Polymers, Typical Thermoplastics, Structure - Property Relationship in thermoplastics, Effect of Temperature on thermoplastics, Mechanical Properties of thermoplastics, Elastomers (Rubbers), Thermosetting Polymers
Ceramic Materials:
Applications of Ceramics, Properties of Ceramics, Characteristics of Sintered ceramics, Glass Ceramics, Refractories.

UNIT – V:
COMPOSITES: TEAMWORK AND SYNERGY IN MATERIAL:

REFERENCES:
2. High temperature technology /Campbell I.E. /John Wiley
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year - I Sem. M.Tech (Thermal Engg.)

THERMAL ENGINEERING LABORATORY

1. Compressibility factor measurement of different real gases.

2. Dryness fraction estimation of steam.

3. Flame propagation analysis of gaseous fuels.


6. COP estimation of vapour compression refrigeration test.

7. Performance analysis of Air conditioning unit.


9. Solar Flat Plate Collector

10. Evacuative tube concentrator
FUELS, COMBUSTION AND ENVIRONMENT

UNIT – I:
Coal – Carbonisation, Gasification and liquefaction – Lignite: petroleum based fuels – problems associated with very low calorific value gases: Coal Gas – Blast Furnace Gas Alcohols and Biogas.

UNIT – II:

UNIT – III:

UNIT – IV:

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

REFERENCES:
2. Fuels and combustion / Sharma and Chander Mohan/ Tata Mc Graw Hill
ENERGY MANAGEMENT

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

UNIT-II

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

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

UNIT-V

REFERENCES:
1. Energy Management Hand Book / W.C. Turner (Ed)
2. Energy Management Principles / CB Smith/ Pergamon Press
ADVANCED FINITE ELEMENT ANALYSIS

UNIT-I
Introduction to FEM, basic concepts, historical background, applications of FEM, general description, comparison of FEM with other methods, variational approach, Galerkin’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.

UNIT-II
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

UNIT-III
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.

UNIT-VI

UNIT-V

REFERENCES:
2. Finite Element Methods: Basic Concepts and applications, Alavala, PHI
3. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall
7. Finite Element Method – Krishna Murthy / TMH
8. Finite Element Analysis – Bathe / PHI
UNIT - I

UNIT – II

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, Euler equations, Navier-stokes system of equations, flow field-dependent variation methods, boundary conditions, example problems.

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.

REFERENCES:
7. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition
UNIT I:

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:

UNIT II:

UNIT III:
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.

UNIT IV:

UNIT V:
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
3. Cooling Towers / J.D. Gurney and I.A. Cotter/ Maclaren
UNIT-I:
Introduction to Forced, free & combined convection – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers.


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.
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:

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:

REFERENCES:
1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David Naylor /McGraw Hill
2. Convective Heat & Mass Transfer /Kays & Crawford/TMH
UNIT I
INTRODUCTION: Sources of energy, Type of Power plants, Direct energy conversion system, Energy sources in India, Recent developments in power generation, Combustion of coal, Volumetric analysis, Gravimetric analysis, Fuel gas analysis.

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

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

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

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

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

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

REFERENCES:

1. Power Plant Engineering / P.K.Naga / TMH
UNIT-I

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.

UNIT-IV

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.

REFERENCES:
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year -II Sem. M.Tech (Thermal Engg.)

REFRIGERATION AND AIR CONDITIONING
(ELECTIVE-IV)

UNIT – I
VAPOUR COMPRESSION REFRIGERATION: Performance of Complete vapor compression system.
Compound Compression: Flash inter-cooling – flash chamber – Multi-evaporator & Multistage systems.

UNIT – II
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.

UNIT – III
AIR REFRIGERATION: Applications – Air Craft Refrigeration -Simple, Bootstrap, Regenerative and Reduced ambient systems – Problems based on different systems.
Steam Jet refrigeration system: Representation on T-s and h-s diagrams – limitations and applications.

UNIT – IV
Cooling load Estimation: Occupants, equipments, infiltration, duet heat gain fan load, Fresh air load.

UNIT – V
AIR –CONDITIONING SYSTEMS: All Fresh air , Re-circulated air with and without bypass, with reheat systems – Calculation of Bypass Factor, ADP,RSHF, ESHF and GSHF for different systems.

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
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
I Year -II Sem. M.Tech (Thermal Engg.)

JET PROPULSION AND ROCKETRY
(ELECTIVE-IV)

UNIT - I:
TURBO JET PROPULSION SYSTEM: Gas turbine cycle analysis – layout of turbo jet engine. Turbo machinery- compressors and turbines, combustor, blade aerodynamics, engine off design performance analysis.
Flight Performance: Forces acting on vehicle – Basic relations of motion – multi stage vehicles.

UNIT - II:
PRINCIPLES OF JET PROPULSION AND ROCKETRY: Fundamentals of jet propulsion, Rockets and air breathing jet engines – Classification – turbo jet , turbo fan, turbo prop, rocket (Solid and Liquid propellant rockets) and Ramjet engines.
Nozzle Theory and Characteristics Parameters: Theory of one dimensional convergent – divergent nozzles – aerodynamic choking of nozzles and mass flow through a nozzle – nozzle exhaust velocity – thrust, thrust coefficient, $A_o / A_t$ of a nozzle, Supersonic nozzle shape, non-adapted nozzles, summer field criteria, departure from simple analysis – characteristic parameters – 1) characteristic velocity, 2) specific impulse 3) total impulse 4) relationship between the characteristic parameters 5) nozzle efficiency, combustion efficiency and overall efficiency.

UNIT - III:

UNIT - IV:
Solid propellant rocket engine – internal ballistics, equilibrium motor operation and equilibrium pressure to various parameters. Transient and pseudo equilibrium operation, end burning and burning grains, grain design. Rocket motor hard ware design. Heat transfer considerations in solid rocket motor design. Ignition system, simple pyro devices.
Liquid Rocket Propulsion System: Liquid propellants – classification, Mono and Bi propellants, Cryogenic and storage propellants, ignition delay of hypergolic propellants, physical and chemical characteristics of liquid propellant. Liquid propellant rocket engine – system layout, pump and pressure feed systems, feed system components. Design of combustion chamber, characteristic length, constructional features, and chamber wall stresses. Heat transfer and cooling aspects. Uncooled engines, injectors – various types, injection patterns, injector characteristics, and atomization and drop size distribution, propellant tank design.

UNIT - V:
RAMJET AND INTEGRAL ROCKET RAMJET PROPULSION SYSTEM: Fuel rich solid propellants, gross thrust, gross thrust coefficient, combustion efficiency of ramjet engine, air intakes and their classification – critical, super critical and sub-critical operation of air intakes, engine intake matching, classification and comparison of IIIRR propulsion systems.

REFERENCES:
1. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & Sons
3. Gas Turbines/Ganesan /TMH
5. Rocket propulsion/Bevere/
6. Jet propulsion/Nicholas Cumpsty/
C programming for problem solving.

Solving Thermal Engineering problems using available packages such as T K Solver, ANSYS, CFX, STARCD, MATLAB, FLUENT etc…