# NRI INSTITUTE OF TECHNOLOGY

An Autonomous Institution, Permanently Affiliated to JNTUK, Kakinada
(Accredited by NAAC with "A" Grade and ISO 9001:2015 Certified Institute)
Pothavarappadu (V), Via Nunna, Agiripalli (M), PIN-521 212.


# COURSE STRUCTURE FOR

# M.TECH

IN

# THERMAL ENGINEERING

.

**DEPARTMENT OF MECHANICAL ENGINEERING**

***SEMESTER-I***

| S.No. | Subject | L | P | C |
|---|---|---|---|---|
| 1 | Optimization Techniques & Applications | 4 | -- | 3 |
| 2 | Advanced Thermodynamics | 4 | -- | 3 |
| 3 | Advanced Heat & Mass Transfer | 4 | -- | 3 |
| 4 | Advanced Fluid Mechanics | 4 | -- | 3 |
| 5 | **Elective – I**<br>1. Gas Dynamics<br>2. Refrigeration & Cryogenics<br>3. Renewable Energy Technologies<br>4. Theory and Technologies of Fuel Cells | 4 | -- | 3 |
| 6 | **Elective – II**<br>1. Advanced IC Engines<br>2. Solar Energy Technology<br>3. Turbo Machines<br>4. Alternative Fuels Technologies | 4 | -- | 3 |
| 7 | Thermal Engineering Lab | -- | 3 | 2 |
| **Total Credits** | | | | **20** |

## *SEMESTER-II*

| S.No. | Subject | L | P | C |
|---|---|---|---|---|
| 1 | Fuels, Combustion & Environment | 4 | -- | 3 |
| 2 | Energy Management | 4 | -- | 3 |
| 3 | Finite Element Method | 4 | -- | 3 |
| 4 | Computational Fluid Dynamics | 4 | -- | 3 |
| 5 | **Elective– III**<br>1. Materials Technology<br>2. Convective Heat Transfer<br>3. Thermal and Nuclear Power Plants<br>4. Advanced Automobile Engineering | 4 | -- | 3 |
| 6 | **Elective– IV**<br>1. Thermal Measurements and Process Controls<br>2. Cryogenic Engineering<br>3. Jet Propulsion and Rocketry<br>4. Equipment Design for Thermal Systems | 4 | -- | 3 |
| 7 | Thermal Systems Design Lab | -- | 3 | 2 |
| **Total Credits** | | | | **20** |

## *SEMESTER-III*

| S. No. | Subject | L | P | Credits |
|---|---|---|---|---|
| 1 | Comprehensive Viva-Voce | **--** | **--** | 2 |
| 2 | Seminar – I | -- | -- | 2 |
| 3 | Project Work Part - I | -- | -- | 16 |
| **Total Credits** | | | | **20** |

## *SEMESTER-IV*

| S. No. | Subject | L | P | Credits |
|---|---|---|---|---|
| 1 | Seminar – II | -- | -- | 2 |
| 2 | Project Work Part - II | -- | -- | 18 |
| **Total Credits** | | | | **20** |

# 18METE101 Optimization Techniques & Applications

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT I:**
Single variable non linear unconstrained optimization: One dimensional minimization methods:- Uni-modal function ,elimination methods, unrestricted search, exhaustive search,, Fibonacci method, golden section method, interpolation method.

**UNIT II:**
Multi variable non-linear unconstrained optimization: Direct search method, search methods, invariant method, pattern search method, Rossen - Brocks method of rotating decent methods, gradient of function, steepest decent method, Fletcher Reeves method, variable metric method.

**UNIT III:**
Geometric programming: Polynomial – arithmetic - geometric inequality – unconstrained G.Pconstrained

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.

**UNIT IV:**
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.

**UNIT V:**
Stochastic programming: Basic concepts of probability theory, random variables- distributions-mean, variance, correlation, co variance, joint probability distribution- stochastic linear, dynamic programming.

**Text Books:**

1. Optimization theory & Applications / S.S.Rao / New Age International.
2. Introductory to operation Reasearch / Kasan & Kumar / Springar
3. Optimization Techniques theory and practice / M.C.Joshi, K.M.Moudgalya/ Narosa Publications

**Reference Books :**

5. S.D.Sharma / Operations Research
6. Operation Reasearch / H.A.Taha /TMH
7. Optimization in operations research / R.LRardin /
1. Optimization Techniques /Chandraputla

# 18METE102 ADVANCED THERMODYNAMICS

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**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:**
**P.V.T SURFACE:** Equation of state. Real gas behavior, Vander Waal's equation, Generalization compressibility factor. Energy properties of real gases. Vapour pressure, Clausius, Clapeyro equation. Throttling, Joule. Thompson coefficient. Non reactive mixtures of perfect gases. Governing laws, Evaluation of properties, Psychometric mixture properties and psychometric chart, Air conditioning processes, cooling towers. Real gas mixture.

**UNIT-III:**
**COMBUSTION:** Combustion Reactions, Enthalpy of formation. Entropy of formation, Reference levels of tables. Energy of formation, Heat reaction, Adiabatic flame temperature generated product, Enthalpies, Equilibrium. Chemical equilibrium of ideal gased, Effect of non reacting gases equilibrium in multiple reactions, The vent hoff's equation. The chemical potential and phase equilibrium. The Gibbs phase rule.

**UNIT-IV:**
**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.

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

**TEXT BOOKS:**
5. Basic and Applied Thermodynamics/ P.K.Nag/ TMH
6. Thermodynamics/Holman/ Me Graw Hill.

**REFERENCES**
5. Engg. Thermodynamics/PL.Dhar / Elsevier

6. Thermodynamics/Sonnatag & Van Wylen / John Wiley & Sons
7. Thermodynamics for Engineers/Doolittle-Messe / John Wiley & Sons
8. Irreversible thermodynamics/HR De Groff.
9. Thermal Engineering / Soman / PHI
10. Thermal Engineering / Rathore / TMH
11. Engineering Thermodynamics/Chatopadyaya/

# 18METE103 ADVANCED HEAT & MASS TRANSFER

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT-I:**

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

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

**UNIT- II:**

**FINITE DIFFERENCE METHODS FOR CONDUCTION**: 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.

**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 coefficienttypes of flow-constant wall temperature and constant heat flux boundary conditionshydrodynamic & 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.

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

**UNIT-V:**

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

**Mass Transfer**: Concepts of mass transfer-diffusion & convective mass transfer analogies-significance of non-dimensional numbers.

**TEXT BOOKS:**

5. Principals of Heat Transfer/Frank Kreith/Cengage Learning
6. Heat Transfer / Necati Ozisik / TMH

**REFERENCES:**

1. Fundamentals of Heat and Mass Transfer-5th Ed. / Frank P. Incropera/John Wiley

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

# 18METE104 ADVANCED FLUID MECHANICS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT I:**

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

**Basic Laws of fluid Flow:** Condition for irrotationality, circulation & vorticity Accelerations in Cartesystems normal and tangential accelerations, Euler's, Bernouli 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 Poisoulle flow - Coutte flow with and without pressure gradient - Hagen Poisoulle flow - Blasius solution.

**UNIT III:**

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

**UNIT IV:**

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

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

**UNIT V:**

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

**Compressible Fluid Flow – II:** Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Releigh Lines, Property Relations – Isothermal Flow in

Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

**TEXT BOOKS:**

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

**REFERENCES:**

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

# 18METE105A GAS DYNAMICS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT I:- Basic concepts :** Introduction to compressible flow, A brief review of thermodynamics and fluid mechanics, Integral forms of conservation equations, Differential conservation equations, Continuum Postulates, Acoustic speed and Mach number, Governing equations for compressible flows

**UNIT II:-One-dimensional compressible flow:** One dimensional flow concept, Isentropic flows, Stagnation/Total conditions, Characteristics speeds of gas dynamics, Dynamic pressure and pressure coefficients, Normal shock waves, Rankine-Hugonoit equations, Rayleigh flow, Fanno flow, Crocco's theorem.

**UNIT III :- Two-dimensional flows:** Oblique shock wave and its governing equations, θ-B-M relations, The Hodograph and Shock Polar, Supersonic flow over wedges and cones, Mach line, Attached and Detached shock, Reflections and interaction of oblique shock waves, Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners, Approximation of continuous expansion waves by discrete waves.

**UNIT IV:- Quasi-one dimensional flows:** Governing equations, Area velocity relations, Isentropic flow through variable-area ducts, Convergent-divergent (or De Laval) nozzles, Overexpanded and under-expanded nozzles, Diffusers.

**UNIT V :- Unsteady wave motions:** Moving normal shock waves, Reflected shock waves, Physical features of wave propagation, Elements of acoustic theory, Incident and reflected waves, Shock tube relations, Piston analogy, Incident and reflected expansion waves, Finite compression waves, Shock tube relations.

**Introduction to experimental facilities:** Subsonic wind tunnels, Supersonic wind tunnels, Shock tunnels, Free-piston shock tunnel, Detonation-driven shock tunnels, and Expansion tubes.

**TEXT BOOKS:**

1. Gas Damics by S.M Yahya
2. Gas Dynamics by Radha Krishnan

**REFERENCES:**

1. Gas Dyanamics by Zucker
2. Dynamics and Thermodynamics of compressible fluid flow (Vol. I, II) by Ascher H.Shapiro
3. Elements of Gas Dynamics by H.W. Liepmann and A. Roshko
4. Fundamentals of Gas Dynamics by V. Babu
5. Modern Compressible Flow by John D. Anderson,Jr.

# 18METE105B REFRIGERATION AND CRYOGENICS

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**Unit-I: VAPOUR COMPRESSION REFRIGERATION SYSTEMS:** Analysis of vapour compression refrigeration cycle

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

**Unit-II: ABSOPTION REFRIGERATION SYSTEM WITH MULTIPLE EVOPARATORS**

Three fluid absorption systems-the Lithium Bromide water absorption system, Steam jet water vapour systems – thermoelectric refrigeration systems – vortex refrigeration system – pulse tube refrigeration. Desirable properties of refrigerants – designation of refrigerants – inorganic, halo carbon refrigerants – inorganic halo carbon reactions- secondary refrigerants – reaction of refrigerants with moisture and oil – properties of mixtures of refrigerants – ozone depletion potential and global warming potential of CFC refrigerants – substitutes for CFC refrigerants

**Unit-III : CRYOGENICS**

Introduction necessity of low temperature - Multistage Refrigeration system -Cascade system - Manufacture of dry ice-Joule Thompson coefficient.

Liquification of air - Linde system- Analysis- Dual pressure cycle analysis-Liquefaction of Hydrogen and Helium-problems.

**UNIT-IV: APPLICATION OF LOWER TEMPERATURES**

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

**UNIT- V: LOW TEMPERATURE INSULATION**

Reflective insulation-Evacuated powders-Rigid foams-Super insulation. Cooling by adiabatic demagnetization - Gas separation and cryogenic systems separation of gases- Rectifying columns- Air separating- single and double columns Air separation plant. Storage and handling of cryogenic liquids - Dewars and other types of containers

**TEXT BOOKS:**

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

**REFERENCE BOOKS**:

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

## 18METE105C RENEWABLE ENERGY TECHNOLOGIES

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT-I**

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

**Solar Energy:** The Sun-sun-Earth relationship, Basic matter to waste heat energy circuit, Solar Radiation, Attention, Radiation measuring instruments.

**Solar Energy Applications:** Solar water heating. Space heating, Active and passive heating. Energy storage. Selective surface. Solar stills and ponds, solar refrigeration, Photovoltaic generation.

**UNIT -II**

**GEOTHERMAL ENERGY:** Structure of earth, Geothermal Regions, Hot springs. Hot Rocks, Hot Aquifers. Analytical methods to estimate thermal potential. Harnessing techniques, Electricity generating systems.

**UNIT-III**

**DIRECT ENERGY CONVERSION: Nuclear Fusion:** Fusion, Fusion reaction, P-P cycle, Carbon cycle, Deuterium cycle, Condition for controlled fusion, Fuel cells and photovoltaic. Thermionic & thermoelectric generation, MHD generator.

**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 bioconversion processed, Raw metrical and properties of bio-gas, Bio-gas plant technology and status, the energetic 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.

**Energy From Oceans**: Tidal energy. Tides. Diurnal and semi-diurnal nature, Power from tides, Wave Energy, Waves, Theoretical energy available. Calculation of period and phase velocity of waves, Wave power systems, Submerged devices. Ocean thermal Energy, Principles, Heat exchangers, Pumping requirements, Practical considerations.

**TEXT BOOK:**

1. Renewable Energy Resources/ John Twidell & Tony Weir/Taylor & Francis/2nd edition

**REFERENCES:**

1. Renewable Energy Resources- Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal/ Narosa Publications
2.Biological Energy Resources/ Malcolm Fleischer & Chris Lawis/E&FN Spon

# 18METE105D THEORY AND TECHNOLOGIES OF FUEL CELLS

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**UNIT I : INTRODUCTION**
Relevance, Principle, various configurations (Alkaline, Acid, Proton Exchange Membrane, direct methanol, molten carbonate and solid oxide fuel cells) fuel cell applications. Basic theory of electrochemistry, electrochemical energy conversion, electrochemical techniques. Thermodynamics of fuel cells. Heat and mass transfer in fuel cells. Single cell characteristics.

**UNIT II: MODELLING**
Electrochemical model. Heat and mass transfer model. System thermodynamic model.

**UNIT III: LOW AND HIGH TEMPERATURE FUEL CELLS**
Proton exchange membrane fuel cell (PEMFC) and direct methanol fuel cell (DMFC): their special features and characteristics. Molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) for power generation, their special features and characteristics.

**UNIT IV: FUELS AND FUEL PROCESSING**
Availability, production and characteristics of Hydrogen , fossil fuel – diverted fuels and biomass- diverted fuels. Principles of design of PEMFC, DMFC and SOFC.

**UNIT V: FUEL CELL SYSTEM**
Materials, component, stack, interconnects, internal and external reforming, system layout, operation and performance.

**TEXT BOOKS:**

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


**REFERENCES:**

1. J., Dick A., Fuel Cell Systems Explained, 2nd Ed. Wiley, 2003.
2. Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006).
3. Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y. (2004) Ref Book.
4. M.T.M. Koper (ed.), Fuel Cell Catalysis, Wiley, Larminie 2009.
5. J.O'M. Bockris, A.K.N. Reddy, Modern Electrochemistry, Springer 1998.

# 18METE106A ADVANCED I.C. ENGINES

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT - I:** 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 – Computer Modeling.

**UNIT - II:**
**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.

**UNIT - III:**
**COMBUSTION IN S.I ENGINES:** Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors, MPFI, SI engine testing P-θ diagram.
**Combustion in CI engines**: Essential Features –Fuel Spray Behavior – Ignition Delay – Mixing Formation and control, Common rail fuel injection system.

**UNIT - IV:**
**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.

**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.
**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.

**TEXT BOOK:**
1. I.C. Engines Fundamentals/J.B Heywood/TMH

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

# 18METE106B SOLAR ENERGY TECHNOLOGY

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**UNIT - I**

Introduction – Solar energy option, specialty and potential – Sun – Earth – Solar radiation, beam and diffuse – measurement – estimation of average solar radiation on horizontal and tilted surfaces – problems – applications. Capturing solar radiation – physical principles of collection – types – liquid flat plate collectors – construction details – performance analysis – concentrating collection – flat plate collectors with plane reflectors – cylindrical parabolic collectors – Orientation and tracking – Performance Analysis.

**UNIT - II**

**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.

**UNIT - III**

**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.

**UNIT - IV**

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

**UNIT - V**

**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.

**TEXT BOOK:**

1. Principles of solar engineering/ Kreith and Kerider/Taylor and Franscis/2nd edition

**REFERENCES:**

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

# 18METE106C TURBO MACHINES

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT-I**:

**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

**UNIT -II:**

**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.

**UNIT-III:**

**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, Diffuser and 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, Degree 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.

**UNIT-V:**

**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.

**TEXTBOOK:**

1. Principles of Turbo Machines/DG Shepherd / Macmillan

**REFERENCES:**


1. Fundamentals of Turbomachinery/William W Perg/John Wiley & Sons
2. Element of Gas Dynamics/Yahya/TMH
3. Principles of Jet Propulsion and Gas Turbine/NJ Zucrow/John Wiley & Sons/Newyork
4. Turbines, Pumps, Compressors/Yahya/TMH
5. Theory and practice of Steam Turbines/ WJ Kearton/ELBS Pitman/London
6. Element of Gas Dynamics/Liepeman and Roshkow/ Dover Publications

# 18METE106D ALTERNATIVE FUELS TECHNOLOGIES

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT I:-**
Fossil fuels and their limitations; Engine requirements; Potential alternative liquid and gaseous fuels.
**UNIT II:-**
Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di-methyl and Di-ethyl ether etc.
**UNIT III:-**
Different ways of using alternative liquid fuels in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance.
**UNIT IV:-**
Use of gaseous fuels like biogas, LPG, hydrogen, natural gas, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels.
**UNIT V:-**
Different approaches like duel fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

**TEXT BOOK:**
1. Alternative Fuels: The Future of Hydrogen, Second Edition**,** Michael Frank Hordeski, CRC Press
**REFERENCES:**
1. Alternative Fuels for Transportation, A S Ramadhas, CRC Press
2. Alternative Fuels & Advanced Technology Vehicles: Incentives & Considerations, Thomas Huber, Jack Spera, Nova Science Publishers.

# 18METE161 THERMAL ENGINEERING LABORATORY

**Practicals : 3 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 2**

1. Compressibility factor measurement of different real gases.
2. Dryness fraction estimation of steam.
3. Flame propagation analysis of gaseous fuels.
4. Performance test and analysis of exhaust gases of an I.C. Engine.
5. Heat Balance sheet, Volumetric Efficiency and air fuel ratio estimation of an I.C. Engine.
6. COP estimation of vapour compression refrigeration test.
7. Performance analysis of Air conditioning unit.
8. Performance analysis of heat pipe.
9. Performance evaluation of Solar Flat Plate Collector
10. Performance evaluation of Shell and Tube heat exchanger.
11. Performance evaluation of combined steam and gas power generation cycle.
12. Measurement of boundary layer thickness over an object using wind tunnel.

# 18METE201 FUELS, COMBUSTION AND ENVIRONMENT

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**UNIT – I:**

**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.

**UNIT – II :**

**PRINCIPLES OF COMBUSTION:** Chemical composition – Flue gas analysis – dew point of products – Combustion stochiometry. 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.

**UNIT – III:**

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

**UNIT – IV:**

**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.

**UNIT – V:**

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

**TEXT BOOK**:

1. Fuels and combustion / Sharma and Chander Mohan/ Tata Mc Graw Hill

**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.

# 18METE202 ENERGY MANAGEMENT

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**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**

**ENERGY AUDIT**: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.

**UNIT-III**

**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**

**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.

**TEXT BOOK:**

1. Energy Management Principles / CB Smith/ Pergamon Press

**REFERENCES:**

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

# 18METE203 FINITE ELEMENT METHOD

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT - I**

**Formulation Techniques:** Methodology, Engineer ing probl ems and governing di f ferent ial equat ions , f ini te element s . , Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions.

**UNIT – II**

**One-dimensional elements:** Bar, trusses, beams and frames, displacements, stresses and temperature effects.

**UNIT – III**

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

**UNIT – IV**

**Isoparametric formulation:** Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, pascal’s triangle, Patch test.

**UNIT – V**

Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages.

**TEXT BOOK**:

**1.** Zienckiwicz O.C. & R. L. Taylor, Finite Element Method, McGraw-Hill,1983.

**REFERENCES:**

1. J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press, 1994
2. Finite element methods by Chandrupatla & Belagundu.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996
4. Concepts And Applications Of Finite Element Analysis, by Witt Plesha Malkus, Robert D Cook 4Th Ed Wiley India Pvt Ltd

# 18METE204 COMPUTATIONAL FLUID DYNAMICS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT – I**

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

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

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

**UNIT – II**

**Hyperbolic equations:** Explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations. Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

**UNIT – III**

**Formulations of incompressible viscous flows**: Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

**Treatment of compressible flows**: potential equation, Eluer equations, Navier-stokes system of equations, flowfield-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.

**TEXT BOOK:**


1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.
2. Computational Fluid Dynamics by John D. Anderson /TMH


**REFERENCE:**


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

# 18METE205A MATERIALS TECHNOLOGY

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**UNIT I:**
Elasticity in metals, mechanism of plastic deformation, slip and twinning, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening. Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity, Yield criteria: Von-mises and Tresca criteria.

**UNIT II:**
Griffth's Theory, stress intensity factor and fracture Toughness, Toughening Mechanisms, Ductile and Brittle transition in steel, High Temperature Fracture, Creep, Larson – Miller parameter, Deformation and Fracture mechanism maps.

**UNIT III:**
Fatigue, fatigue limit, features of fatigue fracture, Low and High cycle fatigue test, Crack Initiation and Propagation mechanism and paris Law, Effect of surface and metallurgical parameters on Fatigue, Fracture of non-metallic materials, fatigue analysis, Sources of failure, procedure of failure analysis. Motivation for selection, cost basis and service requirements, Selection for Mechanical Properties, Strength, Toughness, Fatigue and Creep.

**UNIT IV:**
**MODERN METALLIC MATERIALS**: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides. Processing and applications of Smart Materials, Shape Memory alloys, Metallic Glass Quasi Crystal and Nano Crystalline Materials.

**UNIT V:**
**NONMETALLIC MATERIALS**: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers, Advanced Structural Ceramics WC, TiC, TaC, A12O3, SiC, Si3N4, CBN and Diamond – properties, Processing and applications.

**TEXT BOOKS:**
1. Mechanical Behavior of Materials/Thomas H. Courtney/ McGraw Hill/2 nd Edition/2000
2. Mechanical Metallurgy/George E. Dicter/McGraw Hill, 1998.

**REFERENCES:**
1 Selection and use of Engineering Materials 3e/Charles J.A/Butterworth Heiremann.
2 Engineering Materials Technology/James A Jacob Thomas F Kilduff/Pearson
3 Material Science and Engineering/William D Callister/John Wiley and Sons
4 Plasticity and plastic deformation by Aritzur.

# 18METE205B CONVECTIVE HEAT TRANSFER

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT-I:**
Introduction to Forced, free & combined convection – convective heat transfer coefficient – Application of dimensional analysis to convection – Physical interpretation of dimensionless numbers.
**Equations of Convective Heat Transfer:** Continuity, Navier-Strokes equation & energy equation for steady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layer equations for laminar, turbulent flows – Boundary layer integral equations.
**UNIT-II:**
**EXTERNAL LAMINAR FORCED CONVECTION:** Similarity solution for flow over an isothermal plate – integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flat plate.
**External Turbulent Flows:** Analogy solutions for boundary layer flows – Integral equation solutions – Effects of dissipation on flow over a flat plate.
**Internal Laminar Flows:** Fully developed laminar flow in pipe, plane duct & ducts with other cross-sectional shapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & plane duct flow with developing velocity & temperature fields.
**Internal Turbulent Flows:** Analogy solutions for fully developed pipe flow –Thermally developing pipe & plane duct flow.
**UNIT – III:**
**NATURAL CONVECTION:** Boussineq approximation – Governing equations – Similarity – Boundary layer equations for free convective laminar flows – Numerical solution of boundary layer equations.
Free Convective flows through a vertical channel across a rectangular enclosure – Horizontal enclosure – Turbulent natural convection.
**UNIT – IV:**
**COMBINED CONVECTION:** Governing parameters & equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows - internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct.
**UNIT - V:**
**CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA:** Area weighted velocity – Darcy flow model – energy equation – boundary layer solutions for 2-D forced convection – Fully developed duct flow – Natural convection in porous media – filled enclosures – stability of

horizontal porous layers.

**TEXT BOOK:**

1. Convective Heat & Mass Transfer /Kays & Crawford/TMH

**REFERENCE:**

1. Introduction to Convective Heat Transfer Analysis/ Patrick H. Oosthuigen & David Naylor, MGH

# 18METE205C THERMAL AND NUCLEAR POWER PLANTS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**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 power plant. Power plant cycle, Fuel Handling, Combustion equipment, Ash handling, Dust collectors.
**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.

**TEXT BOOKS:**
1. Nuclear Power Plant Engineering/ James H. Rust/Haralson Publishing Company.
2. Powr Plant Technology / Mohamed Mohamed El-Wakil /Tata McGraw Hill
3. Thermal Engineering in Power Systems/R.S Amano, B. Sunden/WIT Press
**REFERENCES:**
1. Power Plant Engineering / P.K.Nag / TMH
2. Power Plant Engineering / R.K.Rajput/ Lakshmi Publications.
3. Power Plant Engineering / P.C.Sharma/ Kotearia Publications.
4. Power Plant Technology / Wakil.

# 18METE205D ADVANCED AUTOMOBILE ENGINEERING

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT- I:- Transmission systems**

Clutch, gearbox, propeller shaft, differential, axle and wheels

**UNIT- II:- Braking systems**

Mechanical, hydraulic & pneumatic braking systems. Antilock braking systems. Safety and security

**UNIT- III :- Steering & Suspension systems** Mechanical and power steering. Mechanical, electronic and adaptive suspension systems.

**UNIT- IV :- Electrical & Electronic systems**

Wiring circuits, Trouble diagnosis & Trouble shooting, charging, starting and lighting system.

**UNIT- V :- Hybrid vehicles & Motor vehicle act**

Components of hybrid vehicles, Motor vehicle act.

**TEXT BOOKS:**

1. Automobile Engineering – by – Sudhir Kumar Saxena – University science press
2. Automotive Mechanics – by – S. Srinivasan – 2nd ed Mc GrawHill

**REFERENCES:**

1. Automobile Engineering – by – Kirpal Singh, Vol.I & II
2. Automobile Engineering – by – Hitner
3. Automotive Mechanics – by – Crouse, W.H & D.L. Anlin, 1oth Edition, McGrawHill

# 18METE206A THERMAL MEASUREMENTS AND PROCESS CONTROLS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT-I**

**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.

**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**

**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.

**UNIT-V**

**PROCESS CONTROL**: Introduction and need for process control principles, transfer functions, block diagrams, signal flow graphs, open and closed loop control systems – Analysis of First & Second order systems with examples of mechanical and thermal systems. Control System Evaluation – Stability, steady state regulations, transient regulations.

**TEXT BOOK:**

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

**REFERENCES:**

1. Mechanical and Industrial Measurements – R.K. Jain – Khanna Publishers.

2. Mechanical Measurements – Buck & Beckwith – Pearson.
3. Control Systems, Principles & Design, 2nd Edition – M. Gopal – TMH.

# 18METE206B CRYOGENIC ENGINEERING

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**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 gages other than Neon. Hydrogen and Helium.

**UNIT II:**

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

**UNIT-III:**

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

**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.

**TEXT BOOK:**

1. Cryogenic Systems/ R.F.Barren/ Oxford University Press

**REFERENCES:**

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

# 18METE206C JET PROPULSION AND ROCKETRY

**Lectures : 4 Periods / Week** | **Internal Assessment : 40**
**Semester end Exam : 3 hrs** | **Semester end Examination : 60**
**Credits : 3**

**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, Ac / At 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:**

**AERO THERMO CHEMISTRY OF THE COMBUSTION PRODUCTS:** Review of properties of mixture of gases – Gibbs – Dalton laws – Equivalent ratio, enthalpy changes in reactions, heat of reaction and heat of formation – calculation of adiabatic flame temperature and specific impulse – frozen and equilibrium flows.

**Solid Propulsion System:** Solid propellants – classification, homogeneous and heterogeneous propellants, double base propellant compositions and manufacturing methods. Composite propellant oxidizers and binders. Effect of binder on propellant properties. Burning rate and burning rate laws, factors influencing the burning rate, methods of determining burning rates.

**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 IIRR propulsion systems.

**TEXT BOOKS:**

1. Mechanics and Dynamics of Propulsion/ Hill and Peterson/John Wiley & Sons
2. Rocket propulsion elements/Sutton/John Wiley & Sons/8th Edition

**REFERENCES:**

1. Gas Turbines/Ganesan /TMH
2. Gas Turbines & Propulsive Systems/Khajuria & Dubey/Dhanpat Rai & Sons
3. Rocket propulsion/Bevere/
4. Jet propulsion /Nicholas Cumpsty/

# 18METE206D EQUIPMENT DESIGN FOR THERMAL SYSTEMS

**Lectures : 4 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

**UNIT -I:**
**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:

**UNIT-II:**
**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.

**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:**
**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.

**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.

**TEXT BOOK:**

1. Process Heat Transfer/D.Q.Kern/ TMH

**REFERENCES:**

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

# 18METE261 THERMAL SYSTEMS DESIGN LAB

**Practicals : 3 Periods / Week** **Internal Assessment : 40**
**Semester end Exam : 3 hrs** **Semester end Examination : 60**
**Credits : 3**

Using software packages such as T K Solver, ANSYS, CATIA, PRO-E, HYPER MESH, NASTRAN, CFX, STARCD, MATLAB, FLUENT, GAMBIT etc., should design, model, analyze and optimize

(a) Various mechanical components of Steam, Nuclear, gas turbine and Solar power plants.

(b) Heat Exchangers.

(c) Cryogenic systems

(d) Propulsion systems

(e) Refrigeration & Air conditioning systems.

(f) Internal Combustion Engine systems

(g) Internal flows & External flows over stream lined bodies.

(h) Nano-fluid characteristics.

(i) Bio-fuel characteristics.

(j) Wind Energy systems.