JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

ANANTAPUR

Course Structure and Syllabi for Pre Ph.D

MECHANICAL ENGINEERING (2009-10)

PART – I

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	**Thermal Engineering**	**09PH03101**
2	**Mechanical Engineering Design**	**09PH03102**
3	**Industrial Engineering**	**09PH03103**
4	**Advanced Production Technology**	**09PH03104**
5	**Material Technology**	**09PH03105**

PART-II

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	Refrigeration Equipment and Cryogenic Engineering	09PH03201
2	Heat and Mass Transfer	09PH03202
3	I.C. Engines and Alternative Fuels	09PH03203
4	CAD Theory and Practice	09PH03204
5	Mechanical Vibrations and Condition Monitoring	09PH03205
6	Design for Manufacture	09PH03206
7	Special Manufacturing Processes	09PH03207
8	Industrial Robotics	09PH03208
9	Simulation Modeling and Analysis of Manufacturing Systems	09PH03209
10	Advanced Optimization Techniques	09PH03210
11	Logistics and Supply Chain Management	09PH03211
12	Advanced Operations Management	09PH03212
13	Mechanics of Composite materials	09PH03213
14	Energy Conservation	09PH03214
15	Computational Methods	09PH03215

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03101) THERMAL ENGINEERING

Unit 1: Thermodynamic property relations: Availability (Exergy) – Unavailability (Anergy) – Irreversibility – Partial derivatives – Thermodynamic potentials – Maxwell's relations – Clausius Clayperon equation – General relations for du, dh, ds, C_v ,C_p for ideal gases (pure substances) and real gases.

Unit 2: Gas Mixtures: Composition of a Gas mixture – mass and mole fractions – PVT behavior

of gas mixtures (Ideal and Real gases) – Properties of gas mixtures (Ideal and Real gases) Combustion: Theoretical and actual combustion processes – Enthalpy of formation – Enthalpy of Combustion – First Law analysis of Reacting Systems – Adiabatic flame temperature – Entropy change of Reacting mixtures – Second Law analysis of Reacting systems.

Unit 3: Gas power cycles: Carnot cycle - Air standard assumptions - Overview of reciprocating engines - Otto cycle - Diesel cycle – Dual cycle – Stirling cycle – Ericsson cycle – Brayton cycle – Brayton cycle with Intercooling, Reheating and Regeneration.

Vapor power cycles: Carnot vapor cycle – Ideal Rankine cycle – Deviation of Actual Vapor power cycle from Ideal cycle – Actual Rankine cycle – Methods to increase efficiency of Rankine cycle (Lowering of condenser pressure, Super heating steam to High temperature, Increasing Boiler pressure) – Ideal Reheat Rankine cycle – Ideal Regenerative Rankine cycle.

Unit 4: Gas Turbines - Gas Turbine cycle – Combined cycle analysis – Design for high temperature combined cycles with heat recovery boiler – STAG combined cycle power plant – Combined cycle with multi pressure steam, Influence of component efficiencies on cycle performance – Combined cycle with Nuclear power plant – ICGCC plant.

Unit 5: Heat Transfer: Conduction and Single-phase Convection – Introduction – Modes of heat transfer – Combined modes – Steady one-dimensional – Steady heat source system – Forced convection – Boundary layer flow with heat transfer – Equations of momentum and energy – Integral method of solution – Empirical relations for other configurations – Free convection from vertical, horizontal and inclined plates.

Unit 6: Heat Transfer to Fluids with Phase Change – Heating and cooling of fluids in forced convection outside tubes – Heat transfer from condensing vapors – Heat transfer to boiling liquids.

Unit 7:IC Engines: Classification- Engine components, valve timings and mechanism, Spark ignition, four stoke Engine, carburetor, air fuel mixtures, mixture requirements, simple plain tube carbuettor, fuel pump- ignition system, fuel pump and injector, two stroke engine, scavenging of two stroke engine.

Unit 8: Refrigeration: Simple vapour compression cycle, units of refrigeration, reversed carnot cycle for vapour, actual refrigeration cycle, the effect of subcooling, superheating, common refrigerants.

References:

1. **Engineering Thermodynamics by** P.K.Nag /TMH
2. **Thermo dynamics** by Sontag & Van Wylen
3. **Heat Tranfer** by Rajput

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03102) MECHANICAL ENGINEERING DESIGN

Unit 1: Introduction: Introduction to design, the engineering model, computer aided design and Engineering, materials, load analysis, stresses, strains, deflection and stability, stress element representation for different types of loads. Locating critical sections, force flow concept, methodology for solving machine component problems.

Unit 2: Failure Theories: Static failure theories-failure of ductile materials, failure of brittle materials, fracture mechanics, fatigue-failure theories, surface failures.

Unit 3: Design synthesis: Design process and methodologies of systematic design. Conceptual design variants and evaluations. Load transmission, load equalization, lightweight and rigid constructions. Machining considerations. Design of assembly and dismantling, modular constructions. Erection, operation, inspection and maintenance considerations.

Unit 4: Ergonomics. Design of accuracy, locating pins and registers, machining in assembly adjustment. Backlash and clearance adjustment. Problem formulation for design optimization. Examples illustrating the various principles. Available design variants for some of the common basic functional requirements.

Unit 5: Design for Fatigue and Creep: Thermal stress fatigue – creep and rupture of metals of elevated temperature - Hydrogen embrittlement of vessel – Brittle fracture – criteria for design with defects.

Unit 6: Design of power transmission elements: Design of flat belts, v-belts, toothed belts, roller chains, hydrodynamic drives.

Unit 7: Design of Gears: Spur, Helical, Bevel and Worm gears, Gear materials, forces, stresses, lubrication, design procedure considering Lewis beam strength, Buckingham dynamic load and wear load. Algorithms for the design procedure of different types of gears.

Unit 8: Bearings and Lubrication: Lubricants, hydrodynamic lubrication theory, design of hydrodynamic bearings, rolling element bearings, selection of rolling element bearings, bearing mountings and special bearings. Algorithms for the design procedure of bearings.

(PSG Design data book is permitted in examination)

References:

1. **Machine Design –An Integrated approach by** Robert L. Norton, Prentice-Hall, 1998.
2. **Mechanical Design: Theory methodology by** Manjula B Waldron and Kenneth J.Waldron, Springer Verlag, New York, 1996.
3. **Theory and Design of Modern Pressure Vessels by** John F. Harvey, Van Nostrand Reinhold Company New York
4. **Engineering Design: A materials and processing approach** by George Dieter, McGraw-Hill, 1983.
5. **Fundamentals of Machine Component Design by** Robert C. Juvinall and Kurt M. Marshek, John Wiley & Sons, 2nd edition, 1991.
6. **Product Design** by Chitale, P.H.I.

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03103) INDUSTRIAL ENGINEERING

Unit 1: **Industrial Engineering**: Introduction, Definition, objectives, Techniques, Functions of an Industrial Engineer, Role of IE in manufacturing and service organizations .
Productivity: Definition. Benefits, Factors influencing productivity, Partial and total productivity measures.

Unit 2: **Plant Layout**: Economics of plant location, Rural Vs Suburban sites, Types of layouts, Travel chart technique, Assembly line balancing, simple problems.
Materials Handling- Principles, Concept of unit load, Containerization, Palletization, Selection of material handling equipment, Applications of belt conveyors, Cranes, Forklift trucks in industry.
Plant Maintenance: Objectives and types.

Unit 3: Forecasting: Factors affecting forecasting, Sources of data, Forecasting models, Forecast errors, Mean absolute deviation, Mean squared error, Tracking signal.
Production Planning and Control: Types of productions, Production cycle, Product design and development, Process planning, Loading, Scheduling, Dispatching, Routing, Progress, Control, Simple problems

Unit 4: Work Study: Concept of productivity, Method Study - Basic steps in method study, Process charts, Diagrams, Models and Templates, Principles of motion economy, Micro motion study, Therbligs, SIMO chart. Work Measurement - Stop watch procedure of time study, Performance rating, allowances, Work sampling, Simple problems.

Unit 5: Human factors engineering: Introduction to ergonomics and human factors - Engineering physiological basis of human performance - Biomechanics - Psychology of work and work load perception - Physical work environment - Basis of ergonomic problem identification - Safety.

Unit 6: Job evaluation and incentive scheme: Job description and job analysis - Job evaluation-different methods - Individual and group incentive concepts and implications - Different types of incentive schemes - Suggestion schemes

Unit 7: Materials Management: Introduction, Purchasing, Objectives of purchasing department, Buying techniques, Purchase procedure, Stores and material control, Receipt and issue of materials, Store records. Inventory Control, EOQ model(Simple problems).

Unit 8: Statistical Quality Control – Definition, Control charts for variables and attributes. OC curve, Sampling plans, Six sigma, TQM.

References:

1. **Principles of Management** by Koontz & Donnel.
2. **Production and Operations Management** by Everette Adam & Ronald Ebert.
3. **Operations Management** by John McClain & Joseph Thames.
4. **Operations Management Theory and practice** by B.Mahadevan, Pearson.
5. **Production and Operations Management** by R.Panneerselvam, PHI
6. **Industrial Engineering Management**, by Dr. O. P .Khanna

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03104) Advanced PRODUCTION TECHNOLOGY

Unit 1: Metal casting **:** Introduction- solidification of metals – fluid flow – fluidity of molten metal- Heat transfer- defects- design considerations- Economics of casting- foundry and foundry automation.

Unit 2 : Metal casting processes : Sand casting shell moulding – expandable pattern casting - plaster mould and ceramic mould castings- investment casting – vacuum casting – permanent mould casting – slush casting – squeeze casting and semi solid metal forming.

Unit 3: Welding Processes: Oxy-fuel gas welding arc welding – thermit welding – electron beam welding – laser beam welding – weld quality – weld ability – testing – weld design and process selection.

Unit 4: solid state welding processes: cold welding – ultrasonic welding – friction welding. Resistance welding – explosion welding – diffusion welding – super-plastic forming – adhesive joining – joining plastics thermal spraying.

Unit 5: Metal Cutting: Mechanics of chip formation – cutting forces – cutting power – tool life – selection of cutting tool materials and cutting fluids – machining and turning centres – machining – economics.

Unit 6: Advanced Machining Processes: Electrodischarge machining – electro chemical grinding – electon beam machining – abrasive jet machining – nanofabrication – micromachining – rapid prototyping operations – applications.

Unit 7: Processing of Powders, Ceramics and Super conductors: Production, compaction, sintering of powders – design considerations – shaping of ceramics – forming and shaping of glass – processing of super conductors.

Unit 8: Processing of plastics and Composites: Processing methods for plastics, composites, tool making and die making for plastics, composites.

References:

1. **Manufacturing engineering and technology** by Serope Kalpajian, SR Schmid.
2. **Modern materials and manufacturing processes by** RG Bruce, WK Dalton.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03105) MATERIAL TECHNOLOGY

Unit 1: Elasticity in metals and polymers, mechanism of plastic deformation, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening

Unit 2: Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity, deformation of non crystalline material.

Unit 3: 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 4: Fatigue, 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.

Unit 5: Motivation for selection, cost basis and service requirements, Selection for Mechanical Properties, Strength, Toughness, Fatigue and Creep.

Unit 6: Selection for Surface durability, Corrosion and Wear resistance, Relationship between Materials Selection and Processing, Case studies in Materials Selection with relevance to Aero, Auto, Marine, Machinery and Nuclear Applications.

Unit 7: MODERN METALLIC MATERIALS : Dual Phase Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Intermetallics, Ni and Ti Aluminides, Smart Materials, Shape Memory alloys, Metallic Glass, Quasi Crystal and Nano Crystalline Materials.

Unit 8: 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, Al2 O3 , SiC, Si3 N4 , CBN and Diamond : properties, Processing and applications.

References:

1. **Mechanical Behaviour of by** Thomas H. Courtney / 2nd Edition, McGraw Hill,2000.
2. **Mechanical Metallurgy by** George E. Dieter / McGraw Hill,1998.
3. **Selection and use of Engineering Materials** 3e/Charles J.A/ Butterworth Heiremann.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03201)REFRIGERATION EQUIPMENT AND CRYOGENIC ENGINEERING

Unit 1: Compressors - types - equivalent shaft work - Volumetric efficiency - factors affecting total volumetric efficiency - compound compression with inters cooling - rotary compressors - surging - screw compressors - lubricating oils.

Unit 2: . Condensers - types -Water cooled Condensers-Air cooled, Evaporative types - Economic water rate - Economic water velocity - over all heat transfer co-efficient - design - temperature distribution and heat flow in a condenser - pressure drop - fouling factor - LMTD correction factor (no problems).

Unit 3: Cooling towers and spray ponds - classification - performance of cooling towers - analysis of counter flow cooling towers - enthalpy - temperature diagram of air and water - cooling ponds - types - cross flow cooling towers - procedure for calibration of outlet conditions.

Unit 4: Evaporators - types - Flooded and dry Evaporators, natural and forced convection type - shell and tube - shell and coil, plate type - secondary Evaporators - temperature distribution and heat flow in evaporator - pressure drop - fouling correction factor (no problems).

Unit 5: Expansion devices - Capillary tube, thermostatic expansion valve - float valves, externally equalized valves - automatic expansion valves - solenoid control valve - location of piping and pump design consideration.(no problems)

Unit 6: Performance of complete Vapour compression system-Performance of condensing unit-compressor -Evaporator-balancing of load in two stage compression.(no problems)

Unit 7: Liquification of air - Lindae system-Analysis-Dual pressure cycle analysis-Liquefaction of Hydrogen and Helium-problems. Application of Lower temperature-Effects on the properties of metals-strength-Thermal properties-super conductivity-super fluidity.

Unit 8: Cooling by adiabatic de-magnetization - Gas separation and cryogenic systems-separation of gases- Rectifying columns-Air separating- single and double columns Air separation plant. Storage and handling of cryogenic liquids - Dewars and other types of containers.

References:

1. **Refrigeration and Air Conditioning'**- by Stoecker – TMGH– International Edition,1982
2. **Refrigeration and Air Conditioning'** - by Domkundwar – Dhanpat Rai & Co., - 2000
3. **Refrigeration and Air Conditioning'** - by - C.P.Arora – TMGH – 2000
4. **Cryogenics** by Barron. Oxford University Press 1980.
5. **Cryogenic Engineering** by Timmerhaus
6. **Cryogenic Engineering** by Huston: McGraw Hill
7. **Refrigeration and Air-conditioning** by S.Domkundwar.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03202) HEAT AND MASS TRANSFER

Unit 1: Unsteady state heat transfer process by conduction, governing equations and boundary conditions - Two dimensional steady state conduction, semi-infinite and finite flat plate; temperature field in infinite and finite cylinders.

Unit 2: Numerical methods, relaxation method and finite difference methods in heat conduction - simple problems.

Unit 3: Heating and cooling of bodies with negligible internal resistance, sudden changes in the surface temperature of infinite plates, cylinders and semi-infinite bodies-simple problems.

Unit 4: Forced convection in laminar flow - exact and approximate solutions of boundary layer, energy equation for plane isothermal plate in longitudinal flow - problems.

Unit 5: Boiling and condensation: analysis of film condensation on a vertical surface - pool boiling and forced convection boiling inside tubes – problems

Unit 6: Radiation network for an absorbing and transmitting medium, radiation exchange with specular surfaces, radiation exchange with transmissivity and reflecting absorbing medium. Formulation for numerical solution. Solar radiation: Radiation properties of environment, effect of radiation on temperature measurement, the radiation heat transfer coefficient, problems.

Unit 7: Steady state diffusion in dilute solutions in stationary media, transient diffusion in dilute solutions in stationary media, one dimensional non dilute diffusion in gases with one component stationary.

Unit 8: Connective mass transfer - governing equations-forced diffusion from flat plate-Dimension less correlation's for mass transfer. Simultaneous heat and mass transfer - analogy between heat, mass and momentum transfer.

References:

1. **Heat transfer** by J.P. Holman, International student edition
2. **Fundamentals of heat and mass transfer** by R.C. Sachdev New age international publishers.

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03203) I.C. ENGINES AND ALTERNATIVE FUELS

Unit 1: Introduction: Historical Review –Broad classification of fuels - Engine Types – Design and operating Parameters.

Unit 2: Cycle Analysis: Thermo-chemistry of Fuel – Air mixtures, properties – Ideal Models of Engine cycles – Real Engine cycles difference and Factors responsible for – Computer Modeling and simulation of combustion process.

Unit 3: Gas Exchange Processes: Volumetric Efficiency – Flow through ports – Supercharging and Turbo charging. Exhaust gas recirculation system and their designing.

Unit 4: Charge Motion: Mean velocity and Turbulent characteristics – Swirl, Squish – Pre-chamber Engine flows. Fuel supply systems for SI and CI engines to use gaseous fuels like LPG, CNG, and Hydrogen.

Unit 5: Engine Combustion: Combustion and Speed – Cyclic Variations – Ignition – Abnormal combustion Fuel factors.

Unit 6: Combustion in CI engines: Essential Features – Types of Cylinders. Pr. Data – Fuel Spray Behavior – Ignition Delay – Mixing Formation and control:

Unit 7: Pollutant Formation and Control: Nature and extent of problems – Nitrogen Oxides, Carbon monoxide, Un-burnt Hydrocarbon and particulate emission – Measurement – Exhaust Gas Treatment. Catalytic converter, 2 way type & 3 way type.

Unit 8: Modern Trends in IC Engines: Computer Simulation and Optimized Design -Lean Burning and Adiabatic concepts - Rotary Engines. Modification in IC Engines to suite Bio-Fuels

References:

1. **I.C. Engines Fundamentals**/Heywood/Mc Graw Hill
2. **I.C. Engines** /Ferguson
3. **I.C. Engines** / Maleev
4. **IC Engines** / V Ganesan
5. **I.C. Engine in theory and Practice Vol. I and II** / Taylor
6. **I.C. Engines** / Obert / Int.Text Book Co.
7. **Combustion Engine Processes** / Lichty
8. **Scavenging of two stroke Cycle Engines** / Switzer

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03204) CAD THEORY AND PRACTICE

Unit 1: CAD TOOLS:

Definition of CAD Tools, Types of system, CAD/CAM system evaluation criteria, brief treatment of input and output devices. Graphics standard, functional areas of CAD, Modeling and viewing, software documentation, efficient use of CAD software.

Unit 2: GEOMETRICMODELLING:

Types of mathematical representation of curves, wire frame models wire frame entities parametric representation of synthetic curves her mite cubic splines Bezier curves B-splines rational curves

Unit 3: SURFACE MODELING :

Mathematical representation surfaces, Surface model, Surface entities surface representation, Parametric representation of surfaces, plane surface, rule surface, surface of revolution, Tabulated Cylinder.

Unit 4: PARAMETRIC REPRESENTATION OF SYNTHETIC SURFACES:

Hermite Bi-cubic surface, Bezier surface, B- Spline surface, COONs surface, Blending surface , Sculptured surface, Surface manipulation – Displaying, Segmentation, Trimming, Intersection, Transformations (both 2D and 3D).

Unit 5: GEOMETRICMODELLING-3D:

Solid modeling, Solid Representation, Boundary Representation (B-rep), Constructive Solid Geometry (CSG).

Unit 6: CAD/CAM data Exchange:

Evaluation of data – exchange format, IGES data representations and structure, STEP Architecture, implementation, ACIS & DXF.

Unit 7: DESIGN APPLICATIONS:

Mechanical tolerances, Mass property calculations, Finite Element Modeling and Analysis and Mechanical Assembly.

Unit 8: COLLABORATIVE ENGINEERING:

Collaborative Design, Principles, Approaches, Tools, Design Systems.

TEXT BOOKS:

1. CAD/CAM Theory and Practice / Ibrhim Zeid / Mc Graw Hill international.

References:

1. **Mastering CAD/CAM** / Ibrhim Zeid / Mc Graw Hill international.
2. **CAD/CAM** / P.N.Rao / TMH.
3. **CAD CAM: Principles, Practice and Manufacturing Management** / Chris Mc Mohan, Jimmie Browne / Pearson edu. (LPE)
4. **Concurrent Engineering Fundamentals: Integrated Product Development/** Prasad / Prentice Hall, 1996.
5. **Successful Implementation of Concurrent Product and Process** / Sammy G Sinha / Wiley, John and Sons Inc., 1998.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03205) MECHANICAL VIBRATIONS AND CONDITION MONITORING

Unit 1: Single degree freedom systems -Introduction - Single degree freedom systems - free and forced vibrations - Damping classification and damped systems .

Unit 2: Two degree freedom systems - Free, forced damped and undamped motions - Use of influence coefficients, Matrix methods and Lagrange's equations - Phenomenon of beat - Dynamic absorbers – Applications.

Unit 3: Transient (Shock) vibrations as applied to single and two degree freedom systems - Use of mathematics and graphical techniques in the analysis (superposition integral, Laplace transformations, phase plane techniques).

Unit 4: Multi degree freedom systems - Free and forced motions in longitudinal, torsional and lateral modes - damped and undamped, critical speeds of rotors. Continuous systems - free and forced vibrations of string, bars and beams - Principle of orthogonality Classical and energy methods by Rayleigh, Ritz and Gelerkin.

Unit 5: Numerical methods in Vibration Analysis - Introduction-Reduction of Vibration at the source Control of vibration-by structural design-Material selection- Localized additions Artificial Damping- Resilient isolation, Vibration isolation, Vibration absorbers

Unit 6: Condition monitoring methods- Introduction The Design of Information system, Selecting methods of monitoring, Machine condition monitoring and diagnosis.

Unit 7: Vibration Measurements and analysis - Transducers and mounting methods, Data acquisition using instrumentation recorders/data loggers, Time domain signal analysis, Orbit analysis, Filters, Frequency domain analysis (Narrow band FFT analysis), Nyquist criteria, sampling, aliasing, windowing and averaging

Unit 8: Fault Diagnosis, Interpreting vibration measurements for common machine faults, Imbalance, Misalignment, Mechanical looseness, Bearing and Gearing faults, Faults in Induction motors, Resonances, Some case studies.

References:

1. **Mechanical Vibrations** by A.H. Church.
2. **Mechanical Vibrations Practice with Basic Theory** by V. Ramamurthi, Narosa Publishing House.
3. **Mechanical Vibrations** by Den Hartog.
4. **Mechanical Vibrations** by Singiresu S. Rao, Addison Wesley Publishing Co., 1995.
5. **Mechanical Vibrations** by J.O. Den Hartog, Mc Graw Hill, New York, 1985.
6. **Vibration Condition Monitoring of Machines** by Rao J.S., CRS Press, 2000.
7. **Hand Book of Condition Monitoring** by Science Elsevier, Elsevier Science, 1996.
8. **Mechanical fault diagnosis and condition monitoring by** RA Collacott (1977).
9. **The Vibration Monitoring Handbook** (Coxmoor's Machine & Systems Condition Monitoring) (1998).

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

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Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03206) DESIGN FOR MANUFACTURE

Unit 1: Introduction :Design philosophy – steps in Design process – General Design rules for manufacturability – basic principles of designing for economical production – creativity in design.

Unit 2: Materials: Selection of Materials for design – Developments in Material technology – criteria for material selection – Material selection interrelationship with process selection – process selection charts.

Unit 3: Machining Process: Overview of various machining processes – general design rules for machining - Dimensional tolerance and surface roughness – Design for machining, Ease – Redesigning of components for machining ease with suitable examples.

General design recommendations for machined parts.

Unit 4: Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting – casting tolerances – use of solidification simulation in casting design – product design rules for sand casting.

Unit 5: Metal Joining: Appraisal of various welding processes, Factors in design of weldments – general design guidelines – pre and post treatment of welds – effects of thermal stresses in weld joints – design of brazed joints.

Unit 6: Forging – Design factors for Forging – Closed die forging design – parting lines of dies – drop forging die design – general design recommendations –

Unit 7: Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing – Keeler Goodman Forming Line Diagram – Component Design for Blanking.

Unit 8: Plastics: Viscoelastic and creep behavior in plastics – Design guidelines for Plastic components – Design considerations for Injection Moulding – Design guidelines for machining and joining of plastics.

References:

1. **Design for Manufacture** / John Cobert / Adisson Wesley, 1995.
2. **ASM Handbook**, Vol.20.
3. **Engineering Design- A Material and Processing Approach** / George E. Deiter / McGraw Hill Intl., 2nd Edition, 2000.
4. **Product design and Manufacturing** / A.K Chitale and R.C Gupta / Prentice – Hall of India, New Delhi, 2003.
5. **Design and Manufacturing** / Surender Kumar & Goutham Sutradhar / Oxford & IBH Publishing Co. Pvt .Ltd., New Delhi, 1998.

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ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03207) SPECIAL MANUFACTURING PROCESSES

Unit 1: Surface treatment: Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapour deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.

Unit 2: Non-Traditional Machining: Introduction, need ,AJM, Parametric Analysis, Process capabilities, USM -Mechanics of cutting, models, Parametric Analysis, WJM -principle, equipment, process characteristics, performance.

Unit 3: EDM - principles, equipment, generators, analysis of R-C circuits, MRR, Surface finish, WEDM.

Unit 4: LBM - working , equipment , PAM - working , system ,performance

EBM - working , equipment , process parameters

ECM - principle, equipment, mechanical properties, MRR, parameter analysis

Unit 5: Processing of ceramics : Applications, characteristics, classification .Processing of particulate ceramics, Powder preparations, consolidation, Drying , sintering, Hot compaction, Area of application , finishing of ceramics.

UNIT VI:

Unit 6: Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

Unit 7: Fabrication of Microelectronic devices: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in micro electronics, surface mount technology, Integrated circuit economics.

Unit 8: properties of nano-materials, introduction to micromachining, High Speed Machining and rapid prototyping process.

References:

1. **Manufacturing Engineering and Technology** / Kalpakijian / Adisson Wesley.
2. **Process and Materials of Manufacturing** / R. A. Lindburg / PHI
3. **Microelectronic packaging handbook** / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renihold,
4. **MEMS & Micro Systems Design and manufacture** / Tai - Run Hsu / TMGH
5. **Advanced Machining Processes** / V.K.Jain / Allied Publications.
6. **Introduction to Manufacturing Processes** / John A Schey / Mc Graw Hill

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03208) INDUSTRIAL ROBOTICS

Unit 1: Introduction: Robot anatomy, robot configuration, work volume, characteristics, dynamic performance, precision of movement.

End effectors: Grippers-types, operation, mechanism, force analysis, tools as end effectors, consideration in gripper selection and design.

Unit 2: Motion analysis: Manipulator kinematics, Position representation, Homogeneous transformation, DH notation, Forward kinematics, Simple problems applied to different configurations up to 6 dof.

Unit 3: Inverse kinematics, simple problems applied to different configurations up to 6 dof.

Differential kinematics: Diffrerential transformations of 2 dof and 3dof manipulators, Jacobians, Problems

Unit 4: Robot dynamics, D' Alembers method, Newton Euler method and Lagrange Euler method, Simple problems.

Unit 5: SENSORS: Desirable features, Internal and external sensors, Feedback components, tactile, proximity and range sensors, uses sensors in robotics.

MACHINE VISION: Functions, Sensing and Digitizing-imaging, Devices, Lighting techniques, Analog to digital single conversion, Image storage, Image processing and Analysis-image data

reduction, Segmentation feature extraction. Object recognition, training the vision system, Robotics application.

Unit 6: ROBOT PROGRAMMING: Lead through programming, Robot programming as a path in space, Motion interpolation, WAIT, SINGNAL AND DELAY commands, Branching capabilities and Limitations.

ROBOT LANGUAGES: Textual robot languages, Generation, Robot language structures, Elements in function. Programming of various functions in PTP and CP system of robots with suitable examples.

Unit 7: Trajectory planning: theory and problems relating to trajectory path planning

ROBOT CELL DESGIN AND CONTROL: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work design, Work and control, Inter locks, Error detection, Work cell controller.

Unit 8: ROBOT APPLICATIONS: Material transfer, Machine loading/unloading. Processing operation, Assembly and Inspection, Feature Application.

References:

1. **Industrial robotics** / Mikell P.Groover / McGraw Hill.
2. **Robotics: control**, sensing,vision,intellegence / K.S.Fu, R.U. Gonjalez, C.S.G. Lee / McGraw Hill.
3. **Robotics for engineers**, Yoram Koren, McGraw Hill
4. **Industrial Robotics**/ Ganesh S. Hegde/ University Science press

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03209) SIMULATION MODELLING AND ANALYSIS OF MANUFACTURING SYSTEMS

Unit 1: Introduction: History of Manufacturing Systems, Input-Output Model, plant configuration, performance measures, computer controlled machines, material handling systems, plant layout, flexible Manufacturing systems (FMS), Computer Control Systems.

Unit 2: Models: Model Automated Manufacturing systems, Role of performance modeling, Nature of Models, Basic approach to modeling, types of models, analytical Vs simulation models-Need for the both.

Unit 3: Simulation Modeling: The nature of simulation, systems models and simulation discrete event simulation, principles of valid simulation modeling, verification of simulation computer programs, general perspectives on validation, A three-step approach for developing valid and credible simulation models, Random number generators.

Unit 4: Markov Chain Models: Review of basic probability and statistics, Estimation of means and variances, momoryless random variables, geometric and exponential random variables stochatic process in Manufacturing, Discrete time Markov chain models, continuous time Markov chain models, Semi Markov process in manufacturing.

Unit 5: Queuing Models: Queues, the M/M/1 Queue, the M/M/m Queue, batch arrival queuing systems, Queues with general distributions, Queues with breakdowns, Queuing networks, Open and closed queuing networks, Queuing networks with blocking, Performability analysis.

Unit 6: Pertrinet Models: Classical petrinets, Stochastic petrinets, Generalized stochastic petrinets (GSPN), GSPN Modeling of typical manufacturing systems.

Unit 7: Simulation of Manufacturing Systems: Objectives of simulation in manufacturing, simulation software for manufacturing applications, Modeling system randomness, sources of Randomness, Machine downtimes, examples.

Unit 8: Simulation languages – comparison of simulation languages with general purpose languages – Simulation languages vs. Simulators – software features – statistical capabilities – G P S S – SIMAN- SIMSCRIPT –Simulation of M/M/1 queue – comparison of simulation languages.

References:

1. **"Performance Modeling of Automated manufacturing systems" by** N. Viswanadham and Y. Narahari, PHI, 1994.
2. **"Stochastic Models of Manufacturing Systems"** John A. Buzacott, J. George and Shanthi Kumar, Prentice Hall Englewood Cliffs, USA, 1993.
3. **"Simulation Modeling and Analysis" by** Averill M. Law and W. David Kelton,McGraw Hill International Editions, 1997.
4. **"Discrte - Event System Simulation"** Jerry Banks, John S. Carson, Barry L. Nelson and David M. Nicol,Pearson Education International Series in Industrial and Systems Engineering, 2001.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03210) ADVANCED OPTIMIZATION TECHNIQUES

Unit 1: Classical optimization techniques: Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – Solution by method of constrained variation, method of Lagrange multipliers, Kuhn-Tucker conditions.

Unit 2: Numerical methods for optimization: Direct search methods – Random search methods, Nelder Mead's Simplex search method, Hooke and Jeeves' method, Powell's method.

Unit 3: Indirect search methods: Gradient of a function, Steepest descent method, Newton's method, Davidon-Fletcher-Powell method, types of penalty methods for handling constraints.

Unit 4: Geometric programming (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P), Complementary Geometric Programming (C.G.P)

Unit 5: Dynamic programming(D.P): Multistage decision processes. Concepts of sub optimization and Principal of optimality, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P. and continuous D.P.

Unit 6: Integer programming(I.P): Graphical representation. Gomory's cutting plane method. Bala's algorithm for zero-one programming problem. Branch-and-bound method, Sequential linear discrete Programming, Generalized penalty function method.

Unit 7: Stochastic Programming (S.P.): Basic Concepts of Probability Theory, Stochastic Linear programming.

Unit 8: Non-traditional optimization techniques: Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, Simulated annealing, Neural Networks based Optimization.

References:

1. **Engineering Optimization** – S.S.Rao,New Age Publishers
2. **Optimization for Engineering Design** – Kalyanmoy Deb, PHI Publishers
3. **Optimal design** – Jasbir Arora, Mc Graw Hill (International) Publishers
4. **Genetic algorithms in Search, Optimization, and Machine learning** – D.E.Goldberg, Addison-Wesley Publishers
5. **Multi objective Genetic algorithms** - Kalyanmoy Deb, PHI Publishers
6. **Operations Research- Principles and Practice** by Ravindran, Phillips and Solberg, John Wiely
7. **Introduction to Operations Research by Hiller and Lieberman**, Mc Graw Hill
8. **The Essence of Total Quality Management** by John Bank, PHI, 1993.
9. **Beyond Total Quality Management** by Greg Bounds, Lyle Yorks et al, McGraw Hill, 1994.
10. **The Asian Productivity Organization** by Takashi Osada, 1991.
11. **KAIZEN** by Masaki Imami, McGraw Hill, 1986.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03211) LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Unit 1: Logistics and Competitive Strategy: Competitive advantage – Gaining Competitive Advantage through logistic – The Mission of Logistics Management – Integrated supply chains – Supply Chain and Competitive performance – The changing logistics environment – Models in Logistics Management – Logistics to supply Chain Management – Focus areas in supply Chain Management – performance Measures for SCM.

Unit 2: Customer Service Dimension: The marketing and logistics interface – Customer service and customer retention - Service – driven logistics systems – Basic service capability – Increasing customer expectations – Value added services – Customer satisfaction and success – Time based logistics – Case studies.

Unit 3: Logistics System Design: Logistics positioning – Logistics reengineering – reengineering procedure – logistics environmental assessment – time based logistics – alternative logistics strategies – strategic integration – logistics time based control techniques.

Unit 4: Measuring Logistics Costs and Performance: The concept of Total Cost analysis – Principles of logistics costing – Logistics and the bottom line – Impact of Logistics on Shareholder value – customer profitability analysis – direct product profitability – cost driver and activity – based costing.

Unit 5: Logistics and Supply chain relationships: Benchmarking the logistics process and SCM operation – Mapping the supply chain processes – Supplier and distributor benchmarking – setting benchmarking priorities – identifying logistics performance indicators – Channel structure – Economics of distribution – channel relationship – logistic service alliances.

Unit 6: Sourcing, transporting and pricing products: Sourcing decisions in supply chain – transportation in the supply chain – transportation infrastructure – supplier of transport services – basic transportation economics and pricing – transportation documentation – pricing and revenue management in the supply chain – Coordination in the supply chain – pricing and revenue management in supply chains.

Unit 7: Coordination and Technology in Supply chain: Lack of coordination and Bullwhip Effect – Impact of lack of coordination – obstacles to coordination – managerial levers to achieve coordination – Building strategic partners and trust within a supply chain. Role of IT in the supply chain – Customer Relationship Management – Internal supply chain management – Supply chain IT in practice – Information technology and the supply chain – E-business and the supply chain – E –business Framework – case studies.

Unit 8: Managing global logistics and global supply chains: Logistics in a global economy – views of global logistics – global operating levels – interlink global economy – The global supply chains – Global supply chain business processes – Global strategy – Global purchasing – Global logistics – Channel in Global logistics – Global alliances – Issues and Challenges in Global supply chain Management – case studies.

References:

1. **Closs, Logistical Management by** Donald J. Bowersox and David J**.** The Integrated Supply Chain Process, TMH, 2003.
2. **Logistics Supply Chain Management by** Martin Christopher Pitman, London 1993.
3. **Supply Chain Management by** Sunil Chopra and Peter Meindl Strategy, Planning and Operation, 2/e, Pearson Education, New Delhi 2002.
4. **Supply Chain Management for Global competitivesness by** B.S.Sahay Macmillan, NewDelhi, 2003.
5. **Manageing the Global Supply Chain**, Philip B.Schary, Tage Skjott – Larsen Viva, Mumbai, 2000.
6. **Purchasing and Supply Chain Management**- Arjun J Van Weele: Analysis, Planning and Practice, 2/e Thomson Learning, 2000.
7. **Business Logistics/Supply chain management Ballou**,5/e Pearson Education.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03212)ADVANCED OPERATIONS MANAGEMENT

Unit 1: Product design – Requirements of good product design – product development – approaches – concepts in product development – standardization - simplification – Speed to market – Introduction to concurrent engineering.

Unit 2: Value engineering – objective – types of values –function & cost – product life cycle – steps in value engineering – methodology in value engineers – FAST Diagram –Matrix Method.
Aggregate Planning – definition – Different Strategies – Various models of Aggregate Planning-Transportation and graphical models

Unit 3: Advance inventory control systems push systems –Material Requirement – Terminology – types of demands – inputs to MRP- techniques of MRP – Lot sizing methods – benefits and drawbacks of MRP – Manufacturing Resources Planning (MRP –II). Pull systems – Vs Push system – Just in time (JIT) philosophy Kanban System - Calculation of number of Kanbans Requirements for implementation JIT – JIT Production process – benefits of JIT
.

Unit 4: Scheduling: Forward and Backward Scheduling- Master Scheduling- Evaluation of Job Shop Schedules with reference to Priority Scheduling rules, Sequencing, Assignment techniques in Production Scheduling, Line of balance.

Unit 5: Project Management – programming evaluation review techniques (PERT) – three times estimation –critical path – probability of completion of project – critical path method – crashing of simple nature.
Project Appraisal: Criteria for financial appraisal, Payback period, Net present value, Internal rate of return, Profitability index, Capital rationing and selection of projects

Unit 6: Total Quality Management: Philosophy of TQM, Quality Gurus, QC tools, Quality circles, Bench marking, Strategic quality planning, Quality function deployment,

Unit 7: Quality system: Need for ISO 9000 system, Advantages, Clauses of ISO 9000, Implementation of ISO 9000, Quality costs, Quality auditing.
Implementation of TQM: KAIZEN, 5S, JIT, POKAYOKE, Taguchi methods

Unit 8: 6-sigma management – models and case studies – reverse engineering – philosophies and case studies.

Reference:

1. **Total Quality Management** by Rose, J.E., Kogan Page Ltd., 1993
2. **Operations Management"** by E.S. Buffs.
3. **"Operations Management, Theory and Problems**" by Joseph G. Monks.
4. **"Production Systems Management"** by James. L. Riggs.
5. **"Production and Operations Management"** by Chary.
6. **"Operation Management"** by Chase
7. **"Production & Operation Management"** by PannerSelvam
8. **"Production & Operation Analysis"** by Nahima

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03213) MECHANICS OF COMPOSITE MATERIALS

Unit 1: Introduction to composite materials Defination, classification and characteristics of composite materials, Materials-fibrous composites, laminated composites, particulate composites, Introductions to shape memory alloys

Unit 2: Basic concepts and characteristics: Geometric and Physical definitions, natural and man-made composites, applications, types and classification of composites, lamina and laminate characteristics and configurations, constituent materials and properties, properties of typical composite materials.

Unit 3: Coordinate transformations: Transformation of stress and strain, Numerical examples of stress strain transformation, Graphic interpretation of stress – strain relations. Off - axis, stiffness modulus, off - axis compliance.

Unit 4: Elastic behavior of unidirectional composites: Elastic constants of lamina, relation ship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

Unit 5: Strength of unidirectional lamina: Micro mechanics of failure, Failure mechanisms, Strength of an orthotropic lamina, Strength of a lamina under tension and shear maximum stress and strain criteria, application to design. The failure envelope, first ply failure, free-edge effects. Micromechanical predictions of elastic constants.

Unit 6: Characteristics of fibre reinforced lamina Fundamentals, elastic properties unidirectional, continuous fibre zero degree and angle ply lamina

Unit 7: Analysis of laminated composite plates-- same syllabus what u proposed

Unit 8: Applications of composites-- Advantages, disadvantages, limitations and applications of composite

References:

1. **Engineering Mechanics of Composite Materials** by Isaac and M Daniel, Oxford University Press, 1994.
2. **Analysis and performance of fibre Composites by** B. D. Agarwal and L. J. Broutman, Wiley-Interscience, New York, 1980.
3. **Mechanics of Composite Materials by** R. M. Jones, Mc Graw Hill Company, New York, 1975.
4. **Analysis of Laminated Composite Structures by** L. R. Calcote Van Nostrand Rainfold, New York, 1969.
5. **Introduction to composite materials by** Hull and Clyne Cambridge uNIVERSITY
6. **Fiber reinfoRced composites P K MALLICK by** Marcel Dekker , Inc
7. **Mechanics of composite materials** Robert jones Mcgraw Hill Kogakusha Ltd 1998
8. **Composite material hand book Meing Schwaitz** Mcgraw Hill book company 1984

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03214) ENERGY CONSERVATION

Unit 1: HEAT TRANSFER THEORY:

Conduction equation- thermal resistance-combined heat transfer process-heat transfer by conduction (steady state): Radial heat conduction through tubes; through spiracle shells, Composite structures . General equation for forced and free convection- horizontal, vertical plates, flow in side pipe . Radiation- Steffen Boatmen constant- configuration Factor.

Unit 2: HERMODYNAMICS

Availability, energy, and Anergy-Exergy, energy, entropy relationship- Degradation of energy – exergy analysis- exergy conservation- combustion, adiabatic flame temperature, Thermal efficiency, thermal losses; thermal balance sheets-

Unit 3: HEAT EXCHANGER THEORY: types Of heat exchangers - overall heat transfer coefficient – fouling factor - Design of heat Exchangers, L.M.T.D. and N.T.U. methods.

Unit 4: ENERGY CONSERVATION:

Rules for efficient energy conservation – technologies for energy conservation – outline of waste heat and material reclamation, load management, alternative energy sources , Energy storage.

Unit 5: DESIGN FOR THE CONSERVATION OF ENERGY & MATERIAL:

Simulation & modeling – energy flow networks – critical assessment of energy usage, formulation of objectives and constraints- synthesis of alternative options – technical Analysis of option.

Unit 6: THERMAL INSULATION & REFRACTORIES:Heat loss through un insulated and insulated surfaces; effect of insulation on current carrying wires – economic thickness of insulation – critical radius of insulation – properties of thermal insulators – classification of insulation materials – classification of Refractories – properties of refractories – Criteria for good refractory material – application of insulating & refractory materials.

Unit 7: WASTE HEAT RECOVERY SYSTEMS:

Guideline to identify waste heat – feasibility study of waste heat – shell and tube heat exchangers – Thermal wheel – heat pipe heat exchanger – Heat pump – waste heat boilers – Incinerators.

Unit 8: HEAT RECOVERY SYSTEMS:

Liquid to liquid heat exchangers – Gas to gas recovery systems; regenerators , recuperators , rotating regenerators – Miscellaneous heat recovery methods – selection of materials for heat exchangers – combined radiation and convective heat exchanger , U- tube heat exchanger , tubular heat exchanger , fluidized bed heat exchanger –economiser.

References:

1. **Waste heat recovery systems** by D.A. Reay Pergamon press.
2. **Hand book of Energy Audits** by Albert Thumann.
3. **Energy Management** by W.R. Murphy & G. Mickay, Butterworths.
4. **Energy Conservation by** P.W.O. Callanghan, paragamon press 1981.
5. **Engineering Heat transfer by** C.P. Gupta & Rajendra prakesh , Nemchand & bros., Roorke.

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JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANTAPUR

ANANTAPUR

Pre-Ph.D - MECHANICAL ENGINEERING

(09PH03215) COMPUTATIONAL METHODS

Unit 1: Finite differences – Forward, Backward and Central difference approximations to derivatives - Jacobi's Method – Gauss Siedel iterative method

Unit 2: Numerical solution of Partial differential Equations: Implicit method – Explicit method - ADI method – ADE method

Unit 3: Introduction to FEM: Basic concepts – Historical background – General Applications of FEM - General description of the FEM – Comparison of FEM with other methods - Basic element shapes discretization process - Node numbering scheme – interpolation models – convergence requirements - Stress and equilibrium – boundary conditions – stress – strain relations

Unit 4: One dimensional problem – modeling – coordinates and shape functions – Assembly of stiffness matrix and load vector – Properties of stiffness matrix. – Axial bar element – Temperature effects.

Unit 5: Two dimensional problems – modeling – Constant strain triangle – boundary condition –Load vector – Quadrilateral element

Unit 6: Basic equation of heat transfer – steady state heat transfer – 1-D heat conduction – Fin element – 2-D heat transfer.

Unit 7: Modeling of incompressible flows – Stream function – Vorticity equation – Upwind scheme – Estimation of discretisation errors

Unit 8: Finite volume approach – Basic rules – Linearization of source term – 1-D heat conduction – Steady and unsteady – Implicit method – Explicit method – Stability criteria

References:

1. **Introduction to Numerical Methods**/ S.S.Sastry
2. **Numerical Methods** /B.S.Grawel
3. **Computational Fluid flow and Heat transfer** / Edt.K.Muralidhar and T.Sundarrajan / Narosa
4. **Finite Elements in Engineering** / S.S.Rao
5. **Introduction to Finite Element Engineering**/T.R.Chandrupatla and A.D. Belagundu
6. **Numerical fluid flow and Heat transfer** /S.V.Patankar

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