ANNAMACHARYA UNIVERSITY

EXCELLENCE IN EDUCATION; SERVICE TO SOCIETY

(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)

RAJAMPET, Annamayya District, A.P – 516126, INDIA.

MECHANICAL ENGINEERING

Course Structure and Syllabi for Pre Ph.D Programme

SUBJECT -1

S.No.	Course code	Subject Title
1	24CMGT01T	Research Methodology

SUBJECT - 2

S.No.	Course code	Subject Title
1	24CMGT02T	Research Publication and ethics

SUBJECT – 3

Choose any **one** subject from the following list

S.No	Course code	Specialization	Subject Title
1	24CMEC01T	Machine Design	Mechanics of Composite Materials
	24CMEC02T	Thermal	Experimental methods in Thermal engineering
	24CMEC03T	Industrial/ production	Advanced Optimization Techniques
	24CMEC04T	Materials	Nanomaterials Synthesis and Characterization Techniques
	24CMEC05T	Manufacturing	Intelligent Manufacturing Systems

SUBJECT-4

Choose any **one** subject from the following list

S.No.	Course code	Specialization	Subject Title
1	24CMEC06T	Machine Design	Tribology and Bearing Design
	24CMEC07T		Failure Analysis and Design
	24CMEC08T		Finite Element Method
	24CMEC09T		Dynamics and Mechanism Design
2	24CMEC0AT	Thermal	Combustion Thermodynamics
	24CMEC0BT		Phase change phenomena in fluids
	24CMEC0CT		Solar thermal technologies and applications
	24CMEC0DT		Thermal storage system
	24CMEC0ST		Advanced Internal Combustion Engines
3	24CMEC0ET	Industrial/production	Advanced Operations Management
	24CMEC0FT		Tooling for Manufacture in Automation
	24CMECOGT		Design Of Experiments
	24CMEC0HT		Industrial Design & Ergonomics

4	24CMEC0IT	Materials	Materials Characterization
	24CMEC0JT		Advances In Materials and Processing
	24CMEC0KT		Surface Treatment and Finishing
	24CMEC0LT		Bio Material and Technology
	24CMEC0QT		Advanced Material Science and Engineering process
	24CMEC0RT		Technology of surface coatings
5	24CMECOMT	Manufacturing	Simulation Modelling and Analysis of Manufacturing Systems
	24CMEC0NT		Computer Control of Manufacturing Systems
	24CMEC0OT		Advanced Manufacturing Techniques
	24CMEC0PT		Agile Manufacturing

Title of the Course : MECHANICS OF COMPOSITE MATERIALS

Course Code : 24CMEC01T

Unit 1

Basic concepts and characteristics: Geometric and Physical definitions, natural and man- made composites, Aerospace and structural applications, types and classification of composites.

Reinforcements: Fibres- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.

Unit 2

Micromechanics: Unidirectional composites, constituent materials and properties, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. Characterization of composite properties.

Unit 3

Coordinate transformations: Hooke‟s law for different types of materials, Hooke‟s law for two dimensional unidirectional lamina, 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, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

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. Micro mechanical predictions of elastic constants.

Unit 5

Analysis of laminated composite plates: Introduction, thin plate theory, specially orthotropic plate, cross and angle ply laminated plates, problems using thin plate theory.

Manufacturing methods: Autoclave, tape production, moulding methods, filament winding, man layup, pultrusion, RTM.

Prescribed Text Books:

1. Mechanics of composite materials Robert jones Mcgraw Hill Kogakusha Ltd 1998

Reference Books:

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. Composite material hand book Meing Schwaitz Mcgraw Hill book company 1984

Title of the Course : EXPERIMENTAL METHODS IN THERMAL ENGINEERING
Course Code : 24CMEC02T

Unit 1

Introduction: Basic concepts of measurement methods, single and multi point measurement Min space and time. Processing of experimental data, curve fitting and regression analysis. Data Acquisition systems: Fundamentals of digital signals and their transmission, A/D-and D/A converters, Basic components of data acquisition system. Computer interfacing of digital instrument and data acquisition systems; Digital multiplexes, Data acquisition board (DAQ), Digital image processing fundamentals.

Unit 2

Design and Construction of Experimental facilities: wind tunnel, general test rigs, Test cells for flow visualization and temperature mapping.

Modeling and Simulation of Measurement System: Lumped analysis, first order and second order systems: Frequency response and time constant calculation. Response of a generalized instrument to random data input, FFT analysis.

Unit 3

Temperature Measurement: Measurement Design, Construction and Analysis of liquid and gas thermometers, resistance thermometer with wheat stone bridge, Thermo-electric effect, Construction, testing and calibration of thermocouples and thermopiles, Analysis of effect of bead size and shielding on time constant and frequency response, characteristics of thermocouple, pyrometers, radiation thermometers.

Interferometry & Humidity measurement: interferometers, Humidity measurement: Conventional methods, electrical transducers, Dunmox humidity and microprocessor based dew point instrument, Calibration of humidity sensors.

Unit 4

Flow and Velocity Measurement: industrial flow measuring devices, design, selection and calibration, velocity measurements, pitot tubes, yaw tubes, pitot static tubes; frequency response and time constant calculation. Hot-wire anemometer; 2d/3d flow measurement and turbulence measurement, Laser application in flow measurement, Flow visualization techniques, Combustion photography.

Unit 5

Measurement of Pressure, Force, and Torque: Analysis of liquid manometer, dynamics of variable area and inclined manometer, Pressure transducers, Speed and torque measurement: speed and torque measurement of rotating system.

Air Pollution sampling and measurement; Units for pollution measurement, gas sampling technique s, particulate sampling technique, gas chromatography.

Reference Books:

1. **Experimental Methods for Engineers -** J.P. Holman, McGraw-Hill Publications.
2. **Mechanical Measurements -** Beckwith M.G., Marangoni R.D. and LienhardJ.H.,Pearson Education.
3. **Measurements systems-Application and Design -** E.O. Doebelin, Tata McGraw-Hill, Publications.

Title of the Course : ADVANCED OPTIMIZATION TECHNIQUES

Course Code : 24CMEC03T

Unit 1

Linear programming: Two-phase simplex method, Big-M method, duality, interpretation, applications.

Assignment problem: Hungarian‟s algorithm, Degeneracy, applications, unbalanced problems, traveling salesman problem.

Unit 2

Classical optimization techniques: Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – method of Lagrange multipliers, Kuhn-Tucker conditions.

Numerical methods for optimization: Nelder Mead‟s Simplex search method, Gradient of a function, Steepest descent method, Newton‟s method, types of penalty methods for handling constraints.

Unit 3

Genetic algorithm (GA) : Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA.

Unit 4

Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.

Multi-Objective GA: Pareto‟s analysis, Non-dominated front, multi – objective GA, Non- dominated sorted GA, convergence criterion, applications of multi-objective problems .

Unit 5

Applications of Optimization in Design and Manufacturing systems: Some typical applications like optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model ofa machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.

Prescribed Text Books:

1. Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers.
2. Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers.
3. Engineering Optimization – S.S.Rao, New Age Publishers.

Reference Books:

1. Genetic algorithms in Search, Optimization, and Machine learning – D.E.Goldberg,Addison-Wesley Publishers.
2. Genetic Programming- Koza.
3. Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publishers.

Title of the Course : NANOMATERIALS SYNTHESIS AND CHARACTERIZATION TECHNIQUES

Course Code : 24CMEC04T

Unit 1

Nanomaterials: 0D, 1D, 2D structures – Size Effects – Fraction of Surface Atoms – specific Surface Energy and Surface Stress – Effect on the Lattice Parameter – Phonon Density of States – the General Methods available for the Synthesis of Nanostrutures – precipitative – reactive – hydrothermal/solvothermal methods – suitability of such methods for scaling – potential Uses

Unit 2

Physico-chemical methods of nanostructured materials: Solution growth techniques of 1D-2D nano structures:- Synthesis of metallic, semiconducting and oxide nanoparticles – homo- and hetero-nucleation growth methods – template-based synthesis (electrochemical, electrophoretic, Melt and solution, CVD, ALD) – Gas Phase Synthesis of Nanopowders: – Vapor (or solution) – liquid – solid (VLS or SLS) growth – the Need for Gas/vapor State Processing – Main Stages of Gas Phase Synthesis – Applicability of the methods.

Unit 3

Specific features of nanoscale growth: Thermodynamics of Phase Transitions – triggering the Phase Transition – fundamentals of nucleation growth – Controlling Nucleation & Growth – Size Control of the Nanometric State – Aggregation – Stability of Colloidal Dispersions – Spontaneous Condensation of Nanoparticles: Homogeneous Nucleation – Spinodal decomposition – Other undesirable Post-Condensation Effects – Nanoparticles' morphology

Unit 4

Nanoscale properties: Magnetism:- Magnetic Moment in clusters/Nanoparticles – Magnetic Order – coercivity – Magneto crystalline Anisotropy – thermal activation and Superparamagnetic effects – Electronics and Optoelectronics:- Quantum Confinement of Superlattices and Quantum Wells – Dielectric Constant of Nanoscale Silicon – Doping of a Nanoparticle – Excitonic Binding and Recombination Energies – Capacitance in a Nanoparticle – Diffusion.

Unit 5

Characterization of nanophase materials: Fundamentals of the techniques – experimental approaches and data interpretation – applications/limitations of Xray characterization: – X-ray sources – wide angle, extended x-ray absorption technique – Electron microscopy: SEM/TEM – high resolution imaging – defects in nanomaterials – Spectroscopy: – electron energy-loss mechanisms – electron filtered imaging – prospects of scanning probe microscopes – optical spectroscopy of metal/semiconductor nanoparticles

Reference Books:

1. C. N. R. Rao, A. Mu¨ller, A. K. Cheetham, The Chemistry of Nanomaterials :Synthesis, Properties andApplications, Volume 1, Wiley-VCH, Verlag GmbH, Germany (2004).
2. C. Bre´chignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin Heidelberg,Germany (2006).
3. Guozhong Cao, Nanostructures & Nanomaterials Synthesis, Properties G;Z: Applications, World ScientificPublishing Private, Ltd., Singapore (2004).
4. Zhong Lin Wang, Characterization Of Nanophase Materials, Wiley-VCH, Verlag GmbH, Germany (2004).
5. Carl C. Koch, Nanostructured Materials: Processing, Properties and Potential Applications, NoyesPublications, William Andrew Publishing Norwich, New York, U.S.A (2002).

Title of the Course : INTELLIGENT MANUFACTURING SYSTEMS
Course Code : 24CMEC05T

Unit 1

Computer Integrated Manufacturing Systems – Structure and functional areas of CIM system - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems – MAP/TOP, OSI Model, Data Redundancy, Top down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing – System Components, System Architecture and Data Flow, System Operation.

Unit 2

Components of Knowledge Based Systems – Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition. Machine Learning – Concept of Artificial Intelligence, Conceptual Learning, Artificial Neural Networks - Biological Neuron, Artificial Neuron, Types of Neural Networks, Applications in Manufacturing.

Unit 3

Automated Process Planning – Variant Approach, Generative Approach, Expert Systems forProcess Planning, Feature Recognition, Phases of Process planning.

Unit 4

Knowledge Based System for Equipment Selection (KBSES) – Manufacturing system design, Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KBSES.

Unit 5

Group Technology: Models and Algorithms – Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation – Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System, Structure of Knowledge based system for group technology (KBSGT) – Data Baswe, Knowledge Base, Clustering Algorithm.

Prescribed Text Books:

1. Intelligent Manufacturing Systems by Andre Kusaic.
2. Artificial Neural Networks by Yagna Narayana
3. Automation, Production Systems and CIM by Groover M.P.
4. Neural Networks by Wassarman.

Title of the Course : TRIBOLOGY & BEARING DESIGN

Course Code : 24CMEC06T

Unit 1

Introduction to Tribology: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's Poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.

Unit 2

Hydrodynamic Lubrication: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynold's equation in two dimensions with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems

Unit 3

Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.

Unit 4

Antifriction bearings: Advantages, selection, nominal life, static and dynamic load earing capacity probability of survival, equivalent load, cubic mean load, bearing Mountings. **Porous Bearings:** Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages.

Unit 5

Magnetic Bearings: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.

Prescribed Text Books:

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000.

Reference Books:

1. Dudley D.Fulier " Theory and practice of Lubrication for Engineers", New York Company.1998
2. Moore "Principles and applications of Tribology", Pergamon press, 1975.
3. Oscar Pinkus, BenoSternlicht, “Theory of hydrodynamic lubrication”, McGraw-Hill, 1961.
4. G W Stachowiak, A W Batchelor ,“Engineering Tribology”, Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970.

Title of the Course : FAILURE ANALYSIS AND DESIGN

Course Code : 24CMEC07T

Unit 1

Role of Failure Prevention Analysis in Mechanical Design: Introduction, a definition of design, a challenge, some design objectives. **Modes of Mechanical Failure**: Definition of failure mode, failure modes observed in practice, a glossary of mechanical failure modes. Introduction to Fracture Mechanics: An introduction to linear elastic fracture mechanics, use of fracture mechanics design, elastic-plastic fracture mechanics.

Unit 2

High-Cycle Fatigue: Introduction, historical remarks, nature of fatigue, fatigue loading, laboratory fatigue testing, the S-N-P curves, factors that affect S-N-P curves, using the factors in design, the influence of nonzero mean stress, multiaxial fatigue stresses, using multiaxial fatigue failure theories.

Unit 3

Cumulative Damage, Life Prediction and Fracture Control: Introduction, the Linear damage theory, cumulative damage theories, life prediction based on local stress-strain and fracture mechanics concepts, service loading simulation and full scale fatigue testing, damage tolerance and fracture control.

Unit 4

Low-Cycle Fatigue: Introduction, the strain cycling concept, the strain life curve and low- cycle fatigue relationships, the influence of nonzero mean strain and nonzero mean stress, cumulative damage rule in low-cycle fatigue. **Creep, Stress Rupture and Fatigue**: Introduction, prediction of long-term creep behavior, theories for predicting creep behavior, creep under uniaxial state of stress and multi axial state of stress, cumulative creep concept, combined creep and fatigue.

Unit 5

Fretting, Fretting Fatigue and Fretting Wear: Introduction, variables of importance in the fretting process, fretting fatigue, fretting wear, fretting corrosion, minimizing or preventing fretting damage.

Wear and Corrosion: Introduction, wear – Adhesive, abrasive, corrosion, surface fatigue, deformation, fretting, impact, empirical model of zero wear, corrosion, stress corrosion cracking.

Prescribed Text Books:

1. Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention, J. A. Collins, John Wiley & Sons, Inc.

Reference Books:

1. Fatigue of Materials, S. Suresh, Cambridge University Press.
2. Fracture Mechanics: Fundamentals and Applications, T. L. Anderson, CRC Press.

Title of the Course : FINITE ELEMENT METHOD
Course Code : 24CMEC08T

Unit 1

Introduction to Finite Element Method: Engineering Analysis, Convergence criteria, Vibrational formulations, weighted residual methods, Potential Energy 1D Bar Element, Admissible displacement function, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain

Unit 2

One-Dimensional Elements: Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1-D Bar Element, Assembly Procedure, Boundary and Constraint Conditions, 2-D Bar Element, 3-D Bar Element, Beam Element, Hermite shape functions, 1D Heat transfer, Truss element, Test Problems and Applications.

Unit 3

Two-Dimensional Elements : Analysis of Plane Elasticity Problems, Three- Noded Triangular Element (TRIA 3), Four- Noded Quadrilateral Element (QUAD 4), Higher Order Elements Axisymmetric Solid Elements- Analysis of Bodies of Revolution. Axisymmetric Quadrilateral Ring Element- Geometric representation, Admissible displacement functions, Element stain matrix, element stress recovery, Element stiffness matrix, Consistent nodal force vector: Body force, initial strain. Surface traction, Element equations. Test Problems – Assessment of Accuracy, Practical Applications

Unit 4

Three-Dimensional Elements: Applications to Solid Mechanics Problems: Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements.

Unit 5

Dynamic Considerations : Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Prescribed Text Books:

1. Lakshminarayana H. V., Finite Elements Analysis, Procedures in Engineering, Universities Press, 2004.
2. Rao S. S., Finite Elements Method in Engineering, 4th Edition, Elsevier, 2006.
3. Chandrupatla T. R., Finite Elements in Engineering, 2nd Edition, PHI, 2007.

Title of the Course : DYNAMICS AND MECHANISM DESIGN

Course Code : 24CMEC09T

Unit 1

Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms,mobility, Grashoffs law, Equivalent mechanisms, unique mechanisms.

Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary pointmethod, Goodman's indirect method, Numerical examples.

Unit 2

Generalized Principles of Dynamics: Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum.

Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamiltons equations, Hamiltons principle, La0grange's, equation from Hamiltons principle, Derivation of Hamiltons equations, Numerical examples.

Unit 3

Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. Numerical examples.

Unit 4

Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages.

Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.

Unit 5

System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase planeAnalysis, Response of Linear Systems to transient disturbances.

Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. Numericalexamples.

Prescribed Text Books:

1. K.J.Waldron&G.L.Kinzel , "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007.
2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988.

Reference Books:

1. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995
2. A.G.Ambekar , "Mechanism and Machine Theory", PHI, 2007.
3. Ghosh and Mallick , "Theory of Mechanism and Mechanism", East West press

Title of the Course **:** COMBUSTION THERMODYNAMICS

Course Code : 24CMEC0AT

Unit 1

Introduction: Thermodynamics-equation of state, properties of gas mixtures, First law analysis of reacting systems, enthalpy of formation and heat of reaction, stoichiometric and equivalence ratio, adiabatic flame temperature

Fuelsandcombustion: Coal, fuel oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, bio-mass, combustion reactions, heat of combustion and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation. Combustion Mechanisms: Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firing system, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil, combustion of gas, combined gas fuel oil burners, Requirements for efficient combustion , Recent trends in furnace /combustion chamber.

Unit 2

Second law of thermodynamics and concept of chemical equilibrium: Gibbs free energy and the equilibrium constant of a chemical reaction (Vant-Hofts equation). Calculation of equilibrium Composition of a chemical reaction.

Unit 3

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics. **Physics of Combustion:** Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Unit 4

Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame.

Unit 5

Diffusion Flame: Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion, Combustion and Environment: Atmosphere, Chemical Emission from

combustion, Quantification of emission, Emission control methods.

Prescribed Text Books:

1. Mishra, D.P., Introduction to Combustion, Prentice Hall,2009
2. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
3. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988

Reference Books:

1. Thermodynamics – An Engineering Approach, Yunus Cengel and Michael Boles,7th Ed., Tata McGraw Hill
2. Modern Engineering Thermodynamics, Robert Balmer, Elseveir.
3. Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill
4. Principles of Combustion, Kuo K. K., John Wiley and Sons.
5. An Introduction to Combustion concepts and application by Stephen R. Turns, McGraw Hill Higher Education, 2000.

Title of the Course **:** PHASE CHANGE PHENOMENA IN FLUIDS

Course Code : 24CMEC0BT

Unit 1

Fundamentals: Thermodynamic Equilibrium of Binary and Multi-component mixtures: Fugacity and Fugacity Coefficient of Pure Substance and Mixture, Gibbs Phase Rule. **Binary Mixtures:** Phase Equilibrium Diagrams for Binary Mixtures, Ideal Mixtures, Numerical on phase diagrams of ideal mixtures, Raoult's law of mixture, Zeoptrope and Azoetrope mixture Basic Equations on two phase flow: Mass, Momentum and Energy.

Unit 2

Pool Boiling: Boiling regimes, Dimensional Analysis, Nucleate boiling of ordinary fluids, Numerical on nucleate boiling,Film boiling of ordinary fluids, Passive and Active enhancement techniques in heat transfer enhancement.

Unit 3

Flow boiling: Boiling regimes in Horizontal and vertical flow, Nucleate boiling in flow, Saturated boiling in flow, Filmboiling in flow, Flow boiling for binary mixtures and Augmentation techniques inflow boiling.

Unit 4

Flow Patterns and Bubble Dynamics: Flow pattern in Horizontal and vertical tubes: Bubbly flow, plug flow, Stratified flow, Wavy flow, Slug flow and Annular flow. Two phase flow instability: Taylor and Helmholtz instabilities Homogenous and Heterogeneous Nucleation, Rayleigh-Plesset Equation, Bubble Nucleation site density, Bubble size, Bubble departure, Bubble waiting period, Bubble departure and Simple Numerical.

Unit 5

Condensation: Film wise condensation: Laminar condensation of vapour, Condensation on tube banks and Numerical. Dropwise Condensation: Condensation of steam-Factors effecting.

Prescribed Text Books:

1. Convective boiling and condensation by John G. Collier and John R. Thome, Third edition, Oxford Science Publication.
2. Boiling heat transfer and Multiphase flow by L.S Tong, Second edition, Taylor and Francis

Publication.

3. Hand book of Phase Change in Boiling and Condensation by Sathish G. Kandlikar by Taylor and Francis

Reference Books:

1. Fundamentals of Multiphase Flows by Christopher E. Brennen, Cambridge University Press 2005.

Title of the Course **:** SOLAR THERMAL TECHNOLOGIES AND ITS APPLICATIONS

Course Code : 24CMEC0CT

Unit 1

Solar Radiation: Location on earth, celestial sphere, horizon and equatorial system, Instruments for measuring solar radiation and sunshine, description of the various angles depicting the relation between sun and earth, coordinates transformation, solar time, obliquity and declination of the sun, apparent motion of the sun, sun rise and sun set time, east west time, analysis of thedirect daily solar radiation on any arbitrarily located surface.

Unit 2

Flat Plate Collectors: Performance analysis, transmissivity of the cover system, overall loss coefficient and heat transfercorrelations, collector efficiency factor, collector heat removal factor, effects of various parameters on the performance.

Evacuated Tube Collectors: Principle of working, advantages of ETC over FPC, Types of evacuated tubes. Design aspects ofsolar plate collectors.

Unit 3

Concentrating Collectors: Types, description of cylindrical parabolic collector, orientation and tracking modes, performance analysis, parametric study of collector performance in different modes of operation, compound parabolic collector geometry, tracking requirements, parabolic dish collector.

Unit 4

Thermal Energy Storage: Introduction, sensible heat storage: liquids, solids, analysis of liquid storage tank in well mixedcondition and thermal stratification, analysis of packed-bed storage, latent heat storage, thermo chemical storage.

Unit 5

Applications: Water heating systems (Natural and Forced), Industrial process heating system, Active and passive space heating, Solar absorption refrigeration, Power generation (Low Temperature, Medium Temperature, High Temperature), Distillation, Drying, Cooking, Solar Pond. Recent advancement in materials and systems for thermal energy storage systems.

Prescribed Text Books:

1. S.P. Sukhatme, J K Nayak "Solar Energy- Principles of Thermal Collection and Storage", Tata McGraw Hill Company
2. G. D. Rai., "Non- Conventinal Energy Sources", Khanna Publishers, NewDelhi

Reference Books:

1. G.N. Tiwari and S. Suneja, Solar Thermal Engineering Systems, Narosa Publishers.
2. Khan, B.H., "Non-Conventional Energy Resources", Tata McGraw Hill, 2nd Edition, New Delhi.
3. Recent Advancements in Materials and Systems for Thermal Energy Storage, Dott. Andrea Frazzica, Prof. Luisa F.

Title of the Course : THERMAL STORAGE SYSTEM

Course Code : 24CMEC0DT

Unit 1

Introduction: Need of Energy Storage, Different modes of Energy Storage, Necessity of thermal storage, Thermal StorageDevices, Areas of Applications of thermal Storage, Heat Transfer Enhancement Methods.

Unit 2

Sensible Heat Storage system: Basic concept, Modeling of storage System, Water and rock bed storage-use of TRANSYS, Pressurized water storage in power plant, Packed bed storage, Stratified storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage. Chemical Energy Storage, Thermo- Chemical, Bio-Chemical, Electro-Chemical, Fossil fuels and synthetic fuels and Hydrogen storage.

Unit 3

Regenerator: Parallel Flow, Counter Flow, Finite conductivity model, Non-linear Model, Transient Performance, Step Change in inlet gas temperature, Step Change in inlet gas Flow rate, Parameterization of Transient Response, Heat Storageexchangers

Unit 4

Latent Heat Storage: Storage material modeling of phase change problem, Enthalpy Modeling, Heat Transfer EnhancementConfiguration, Parameterization of Rectangular, Cylindrical Geometric Problems, Phase Change Materials(PCMs), Selection Criteria Of PCMs, Stefan Problem, Solar Thermal LHTES Systems, Energy Conservation Through LHTES Systems, LHTES Systems in Refrigeration and Air Conditioning Systems.

Unit 5

Applications of Thermal Storage System: Food storage, Waste heat recovery, Solar energy storage, Green house heating,Drying and heating applications, Power Plant Applications, Drying and Heating for Process Industries

Prescribed Text Books:

1. F. W. Schmidt and A.J. Willimot, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.
2. V J Liunardini, Heat Transfer in Cold Climate, D Van Nostrand Reinhold, NY, 1981.
3. Ibrahim Dincer and Marc A. Rosen, Thermal Energy Storage System and Applications.

Title of the Course **:** ADVANCED INTERNAL COMBUSTION ENGINES

Course Code : 24CMEC0ST

Unit 1

Introduction: Basic Nomenclature, Classification of IC Engines, working principle of 2-stroke and 4-stroke SI and CI engines. Air stand, fuel-air and actual cycles CI engines. Engine performance parameters. Valve and port timing diagrams.

Unit 2

Combustion: *CI Engines* - Combustion initiation, Flame development and propagation, ignition lag, preignition, normal and abnormal combustion-knocking, physical and chemical aspects of knocking, design considerations of combustion chamber

Unit 3

Engine Accessories: **CI Engine**- Fuel pump, Fuel injection system, types of fuel injectors, flywheel, high pressure pipe - Requirement, types of nozzle, atomization, spray penetration and spray direction, multiple point fuel injection system, injection timing, common rail fuel injection system.

Unit 4

Cooling and Lubrication Systems: Cooling requirement, air cooling, liquid cooling, type of liquid cooling system, advantage and disadvantage of air cooling and water cooling system, Antifreeze mixture. Function of lubricating system, properties of lubricating oil, wet sump, dry sump and mist lubrication system

Unit 5

Fuels: Basic requirement of I.C. Engine fuels, requirement of an ideal gasoline, volatility of liquid fuels, effect of volatility on engine performance for starting, vapor lock, Alternative fuels, Compressed Natural Gas, Hydrogen Energy- Solid, Liquid, Gas. Fuel Cells. **Emissions:** Emissions CI engines, emission control system, types of emission control system, EGR system.

Reference Books:

1. **J. B. Heywood,** Internal Combustion Engine, McGraw Hill, ISBN-0- 188 07-100499-8;
2. **V. Ganeshan,** Internal Combustion Engine, Tata McGraw Hill, 1992.
3. **M.L. Mathur and R.P. Sharma,** A Course in Internal Combustion Engines, Dhanpat Rai and Sons
4. **V. Ganeshan,** Computer simulation of SI Engine Process, Orient, 1996.

Title of the Course : ADVANCED OPERATIONS MANAGEMENT

Course Code : 24CMEC0ET

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. 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 2

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 3

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. 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 4

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

Unit 5

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 method, 6-sigma management – models and case studies – reverse engineering – philosophies and case studies.

Reference Books:

1. **Total Quality Management** by Rose, J.E., Kogan Page Ltd., 1993
2. **Operations Management"** by E.S. Buffs., C.B. Publishers.
3. **"Operations Management, Theory and Problems**" by Joseph G. Monks, Mc Grow Hill book Company-Koga.
4. **"Production Systems Management"** by James. L. Riggs, John wiley & Sons Inc.
5. **"Production and Operations Management"** by Chary, TaTa Mc Grow-Hill
6. **"Operation Management"** by Chase, Mc Graw-Hill
7. **"Production & Operation Management"** by Panner Selvam PHI
8. **"Production & Operation Analysis"** by Nahima

Title of the Course **:** TOOLING FOR MANUFACTURE IN AUTOMATION

Course Code : 24CMEC0FT

Unit 1

Mechanics of Metal Cutting: Introduction, measurement of cutting forces and chip thickness, force components, chip formation and primary plastic deformation, shear plane and slip line theories for continuous chip formation.

Modern Cutting Tool Materials: Material properties, HSS related materials, sintered tungsten carbide, cermets, ceramics,polycrystalline tools, tool coatings.

Cutting tools: Basic types of cutting tools, turning tools, indexable inserts, groove geometry, edge preparation, wipergeometry, insert clamping methods, tool angles, threading tools, cutters.

Unit 2

Optimization: Machining cost and production rate verses cutting speed, role of computerized optimization system, economic considerations, optimization of machining system.

Tooling Requirements for CNC Machines: Tool holding systems modular and quick change tool holding system, tool holderspindle connection, cutting tool clamping systems, milling cutter driver, side lock type chuck, collet chucks, hydraulic chucks, milling chucks. Tool magazines, Automatic tool changers.

Unit 3

Location and Clamping Methods: Basic principles of locating, locating methods &devices, Basic principles of clamping,clamping methods.

Fixtures: Definitions, General considerations, Machine considerations, Process considerations, Product considerations, Typesof fixtures, Vise fixtures, Milling fixtures.

Unit 4

Fixtures for Automation: Work holders for CNC, Fixturing in FMS: Part holding on Pallets, standard fixtures, pallet changers, pallet pool, flexible fixturing – principles and methodologies, modular fixturing system: T slot based, dowel pinbased, fixturing components.

Unit 5

Plastics for Tooling Materials: Introduction, Commonly used plastics for tooling, Epoxy plastics tools, Construction methods, Urethane dies, Force calculation for Urethane pressure pads.

Prescribed Text Books:

1. Cyrol Donaldson, Tool Design -, Tata McGraw Hill, India.
2. Edward G Hoffman, Fundamentals of Tool Design -, SME, USA.
3. Joshi, P.H., Jigs & Fixtures, Second Edition, Tata McGraw-Hill, New, Delhi 2004
4. Hiram E Grant, Jigs and Fixture Tata McGraw-Hill, New Delhi, 2003

Reference Books:

1. William E Boyes, Handbook of Jigs & Fixtures Design -, SME, USA
2. G.R. Nagpal, Tool Engineering & Design -, Khanna publications
3. David A.Stephenson, John S. Agapiou, Metal cutting theory and practice, Second edition CRC taylor and Francispublishers
4. Dr. B.J. Ranganath, Metal cutting and tool design, Vikas publishing house
5. ASTME; Die Design Hand book; McGraw Hill.

Title of the Course **:** DESIGN OF EXPERIMENTS

Course Code : 24CMEC0GT

Unit 1

Introduction: Brief introduction of optimization techniques, Strategy of experimentation, Basic principles of Design, Terminology used in Design of Experiment, Guidelines for designing experiments, Basic statistical concepts: Types of Data, Graphical representation of Data, Measures of Central Tendency and Dispersion, Skewness.

Unit 2

Fitting Regression models: Introduction, Linear regression models, Estimate of parameters in linear regression models, The method of least square, Hypothesis testing: Null Hypothesis, Alternative Hypothesis, Prediction of new response observations, Testing for lack of fit.

Unit 3

Factorial Design : Basic definition and principles, Advantages of factorials, Types of factorial design: Full factor factorial design and fraction factorial design, Design Matrix, Development of mathematical model, Regression model diagnostics

Unit 4

Taguchi Method : Introduction, Concept design, Parameter design, Tolerance design, Orthogonal array experiments Taguchi quality loss function, Signal-to Noise ratio, Quality characteristics, Parameter optimization experiment, Parameter design case study.

Unit 5

Analysis Of Variance (ANOVA): Introduction, One way ANOVA process, Two way ANOVA process, Degrees of freedom, Case studies on Factorial design, Taguchi Method and ANOVA.

Reference Books:

1. Montgomery D. C., Design and Analysis of Experiments, John Wiley.
2. John P. W. M., Macmillan, Statistical Design and Analysis of Experiments.
3. Taneja H. C., Statistical Methods for Engineering and Sciences, IK International Publishing house Pvt Ltd.
4. Barnes J. Wesley, Statistical Analysis for Engineers And Scientists, McGraw Hill Inc

Title of the Course **:** INDUSTRIAL DESIGN & ERGONOMICS

Course Code : 24CMEC0HT

Unit 1

Introduction: An approach to industrial design - elements of design structure for industrial design in engineering application in modem manufacturing systems. Ergonomics and Industrial Design: Introduction - general approach to the man-machine relationship- workstationdesign-workingposition.

Unit 2

Control and Displays: shapes and sizes of various controls and displays-multiple displays and control situations - design ofmajor controls in automobiles, machine tools etc., - design of furniture – design of instruments.

Unit 3

Ergonomics and Production: Ergonomics and product design ergonomics in automated systems- expert systems for ergonomic design, Anthropomorphic data and its applications in ergonomic design limitations of anthropomorphic data- use of computerized database.

Unit 4

Visual Effects of Line and Form: The mechanics of seeing psychology of seeing, general influences of lined and form. Colour: colour and light - colour and objects - colour and the eye colour consistency - colour terms - reactions to colour and colour continuation colour on engineering equipment.

Unit 5

Aesthetic Concepts: Concept of unity - concept of order with variety - concept of purpose style and environment - Aestheticexpressions. Style-components of style - house style, observations style in capital goods.

Industrial Design in Practice: General design - specifying design equipments - rating the importance of industrial design –industrial design in the design process.

Prescribed Text Books:

1. Industrial design for Engineers - Mayall W.H. - LondonCliffee Books Ltd.
2. Applied Ergonomics Hand Book - Brien Shakel (Edited) - Butterworth Scientific,

Title of the Course : MATERIALS CHARACTERIZATION

Course Code : 24CMEC0IT

Unit 1

X-Ray based characterization Principles and applications of X-ray diffraction, powder (polycrystalline) and single crystalline XRD techniques; Debye-Scherrer equation to treat line broadening and strain induced in nanoparticles and ultra-thin films. X-ray photoelectron spectroscopy – basic principle, instrumentation and application.

Unit 2

Electron microscopy techniques Introduction, Principles and applications of Electron beam, Electron beam interaction with matter. Scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM/HRTEM), Electron-diffraction (SAED), Atomic Force Microscope

Unit 3

UV-VIS Spectrophotometers- Principles, operation and application for band gap measurements. IR/FTIR Spectrophotometers- Principles, sample preparation, operation and application. Raman spectroscopy-principles and applications. Optical microscope: Nanoparticle size measurement by Dynamic light scattering method. Atomic Absorption Spectroscopy - Instrumentation, Principal, Advantages and disadvantages of AAS, Instrumentation and application. Inductively Coupled Plasma Spectroscopy-Instrumentation, principle and Applications.

Unit 4

Thermal methods: Principle, instrumentation and working Thermo gravimetric analyses (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).

Unit 5

Potentiometry: Types of Electrodes, Reference and indicator electrodes, Glass electrode, Ion- selective electrodes. Volta metric principles, stripping voltammetry, cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis, linear sweep voltammetry, Chronoamperometry,

Reference Books:

1. Instrumental Methods of Analysis 7th editionWillard, Merritt, Dean, Settle
2. Scanning Probe Microscopy: Analytical Methods (NanoScience and Technology) Roland Wiesendanger
3. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials Harold P. Klug, Leroy E. Alexander 2nd Edition
4. Transmission Electron Microscopy: A Textbook for Materials Science David B. Williams and C. Barry Carter (4-Vol Set)
5. A.J.Bard and L. R. Faulkner, Electrochemical Methods, Fundamentals and applications, John Wiley, 1980
6. Skoog, D.A., Holler, F.J., and Crouch, S.R.,^{3}P^{5}r^{8}inciples of Instrumental Analysis, Thomson Learning (2007).
7. Elton N. Kaufmann, Characterization of Materials, Vol.1, Wiley & Sons (2003)
8. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Wiley & Sons(2008)
9. Sam Zhang, Lin Li and Ashok Kumar, Materials Characterization Techniques, CRC Press, (2008)

Title of the Course **:** ADVANCES IN MATERIALS AND PROCESSING

Course Code : 24CMEC0JT

Unit 1

Classification and Characteristics: Metals, Nonferrous Metals and Ferrous Metals, classification of Ferrous Metals and Non- Ferrous Metals, Types of Ceramics, Polymers and composites and classification of composites. General Properties and Structure: Atoms, molecules bonds in solids, Crystalline – Defects in Metallic structure, Dislocations and plastic deformation -
Strengthening mechanism – grain size, dislocation - Cold work, precipitation hardening, dispersion hardening - phasereactions, fatigue and Creep behavior.

Unit 2

Ferrous Alloys: iron carbon equilibrium diagrams - Steels and cast irons - properties, structure, composition and applications transformation hardening in steels - TIT diagrams - Heat treatment processes - Effect of alloying elements - High alloy steels,Stainless steel types, tool Steels, Manganese steels, heat resistant steels, HSLA, Managing steels. Non-Ferrous Alloys: Alloysof copper, Aluminum, nickel, magnesium, titanium, lead, tin, Zinc - composition, heat treatment, structure, properties and application.

Unit 3

Polymers and Polymerizations: Structure and properties of thermoplastics and thermosets – Engineering Applications - property modifications - Mechanical and thermal behaviour – processing methods Ceramics: Nature and structure of Ceramics-Refractory Abrasives glasses - glass ceramics - Advanced ceramics processing methods.

Unit 4

Composites: Definition - classification and characteristics of composite materials - Volume fraction - laminated composites particulate composites, fibrous composites – Types of reinforcements, their shape and size - production and properties of fiberreinforced plastics, Metal Matrix composites and ceramic matrix composites - Applications.

Unit 5

Processing of Polymers: composites, ceramics - thermal spraying - Ion beam machining diamond coating techniques-tribological applications.

Prescribed Text Books:

1. Advanced Materials and Processes - James W. Evans Lutgard C. De Jonghe. Springer Publications – 2016.
2. Engineering Metallurgy - Raymond and Higgens - ELBS/EA
3. Introduction to Material Science and Engineering James. F. Shackleford - Mc Millan, NY - 7th edition.

Reference Books:

1. Powder Metallurgy-Metals Hand Book -ASM, USA - Vol.7, 1974.
2. Composite Materials - Science and Engineering - Chawla K.K. , - Springer - Verlag, New york – 2nd edition, 1998.
3. Cast Metal Matrix Composites ASM Metals Hand Book - P.K. Rohagti - VI5.
4. Elements of Material Science and Engineering - Van Vlack L.H. - Addison Wesley, NY- 1989.
5. Material science and metallurgy - by Callister, John Willey & Sons.

Title of the Course **:** SURFACE TREATMENT & FINISHING

Course Code : 24CMEC0KT

Unit 1

Fundamentals of Electro plating: galvanizing, Hot dip metal coating, thin coating, thin coating, chromium plating, Nickel plating

Unit 2

Vacuum coating, **FVD & CVD metal spraying** – Methods, surface preparation, mechanical properties of sprayed metals,plasma coating.

Unit 3

Plastic coating of metal - PVC coating, Spherodising process details, phosphate coating - mechanism of formation, Testing of surface coating-methods.

Unit 4

Heat treatment methods, Annealing, Normalizing, Tempering, Case hardening methods, flame hardening sub zero treatment, Heat treatment methods for gears, spindles, cutting tools.

Unit 5

Advanced coating technologies: Hard facing, electro deposition technique, nano-coatings, coating characterization.

Prescribed Text Books:

1. Surface preparations & finishes for Metals - James A Murphy - McGraw Hill.
2. Principles of metal surface treatment and protection - Pergamon Press Gabe, David Russell - Oxford ; New York - 2d ed., 1978.

Title of the Course **:** BIO MATERIAL AND TECHNOLOGY

Course Code : 24CMEC0LT

Unit 1

Introduction: Definition of Bio material, Classification of Bio materials, Comparison of properties of some common bio materials, effects of physiological fluid on properties of biomaterials, surface properties, physical and Mechanical properties of Bio materials. Metallic Implants Materials: Stainless Steel, Co-based alloys, Ti and Ti based alloys, Important of stress corrosion cracking, Host tissue reaction with Bio metal, corrosion behaviour, hardtissue replacement implant, orthopaedic implant, dental implants, Percutaneous and skin implants, Vascularimplants, Heart valve implant.

Unit 2

Polymeric Implant Materials: polyolefins, polyamides, acrylic polymers, fluoro carnon polymers, Silicon rubber acetals. Visco elastic behaviour, creep recovery, stress relaxation, strain rate sensitivity, importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives, aging and environmental stress cracking, physiochemical characteristics of bio polymers, bio degradable polymers for medical purpose and their biological applications. Ceramic Implant Materials: Definitions of Bio ceramics, common type of Bio ceramics, Aluminium oxides, Glass ceramics, Carbons. Bioresorbable and Bioactive ceramics, Importance of wear resistanceand low fracture toughness. Host Tissue reactions, Importance of Interfacial tissue reaction.

Unit 3

Composite Implant Materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement, polymers filled with osteogenic fillers (e.g. hydrosyapatite). Host tissue reactions. Bio Compatibility And Toxicological Screening Of Bio Materials: Definition of bio compatibility, bloodcompatibility and tissue compatibility, toxicity tests, acute and chronic toxicity (in situ implantation, tissue culture,haemolysis, thrombogenic, potential test, systemic toxicity, intracutaneous irritation test), sensitization,carcinogenicity, mutagenicity and special tests.

Unit 4

Testing of Bio Materials Implants: In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. In vivo testing (animals): biological performance of implants. Exo- vivotesting, standards of implant materials.

Unit 5

Sterilisation Techniques: ETO, gamma radiation, autoclaving, Effects of Sterilisation on material properties.

Prescribed Text Books:

1. Biological performance of materials, Jonathan Black, MarceDecker,1981.
2. Blood Compatible Materials and Devices, C.P. Sharma & M. Szyehen, Technonic Publishing Co Ltd.,1991.

Reference Books:

1. Polymetric Biomaterials. Piskin and S.Hofmann Mantinus Nijhoff publication bordrechnt 1986.2
2. Biomaterials, Science and engineering, J.B. Park, Plenum Press 1984
3. Biomaterials, Sujata V. Bhat, Narosa Publishing House – 2002.

Title of the Course : ADVANCED MATERIAL SCIENCE AND ENGINEERING PROCESS

Course Code : 24CMEC0QT

Unit 1

Classification and Characteristics: Metals, Nonferrous Metals and Ferrous Metals, classification of Ferrous Metals and Non- Ferrous Metals; composites and classification of composites.

General Properties and Structure: Atoms, Molecules bonds in solids, Crystalline – Defects in Metallic structure, Dislocations and plastic deformation - Strengthening Mechanism – Grain size.

Unit 2

Non-Ferrous Alloys: Alloys of copper, Aluminum, Nickel, Magnesium, Titanium, Lead, Tin, Zinc – compositions; Heat Treatment, Structures, properties and applications.

Ferrous Alloys: Iron Carbon Equilibrium Diagrams - Steels and cast irons - properties, structure, composition and applications; Transformation Hardening in steels - TIT diagrams - Heat treatment processes.

Unit 3

Casting and Transformation processes: Classification, characteristics of sand casting processes, Metal Mould Casting Processes; Advanced casting: Principle of Stir casting, steps in stir casting process, Factors affecting stir casting process: stirring speed ,stirring time and stirring temperature, preheat temperature of the Mould, Particle Distribution, wettability between Reinforcement and Liquid Metal and Porosity - Advantages and Applications.

Unit 4

Taguchi Method: Introduction, Concept design, Parameter design, Tolerance design, Orthogonal array Experiments , Signal-to Noise ratio, Quality characteristics, Parameter optimization experiment.

Analysis Of Variance (ANOVA): Introduction, One way ANOVA process, Two way ANOVA process, Degrees of freedom, Factorial design, Taguchi Method and ANOVA.

Unit 5

Materials Characterization: Electron Microscopy Techniques, Introduction, Principles and Applications of Electron beam, Electron Beam Interaction with matter, Scanning Electron Microscopy (SEM/FESEM), Transmission Electron Microscopy (TEM/HRTEM), Electron-Diffraction (SAED), Atomic Force Microscope. Fundamentals of X-ray scattering, X-Ray Based Characterization, Principles and applications of X-ray Diffraction.

Text Book:

1. Engineering Metallurgy - Raymond and Higgens - ELBS/EA.

2. Introduction to Material Science and Engineering James. F. Shackleford - Mc Millan, NY - 7th edition.

3. Advanced Materials and Processes - James W. Evans Lutgard C. De Jonghe. Springer Publications – 2016.

Reference Books:

1 Design of Experiments with Minitab, Paul Mathews, New Age International.

2. Elements of Material Science and Engineering - Van Vlack L.H. - Addison Wesley, NY- 1989.

3. Material science and metallurgy - by Callister, John Willey & Sons.

Title of the Course : TECHNOLOGY OF SURFACE COATINGS

Course Code : 24CMEC0RT

Unit-1: Basics concepts

The nature of paint, ingredients of pints, Classification of paints-High build, high solids and solvents paints, application of paints-Paint film, Coverage rage and pigmentation volume concentration.

Unit-2: Drying oils, driers and drying

The drying process, Types of drier compounds, Extraction of oils, Linseed oil, Tung oil, Dehydrated castor oil, modified drying oils. Water-borne paints-Polymer emulsions, vinyl emulsions paints, materials and manufacturing of vinyl emulsions paints, acrylic emulsions and paints, Water soluble binders.

Unit-3: Process of pigmentation, Methods of pigment dispersion

Non-Aqueous Paints-Breakdown of aggregates, wetting of pigment partials Stabilization of dispersion, Water soluble paints, Aqueous emulsion paints. Pigment dispersion-Plastic milling pug mixtures, fluid milling, mills which require pre mixing, straining.

Unit-4: Testing and evaluation.

Testing of pigments, extenders, oils, resins, solvents, testing of liquid paints, Application and wet films, Sag resistance, drying time, measurement of drying time, over coting time. Tests on dry films- mechanical properties, optical properties; chemical resistance and corrosion resistance

Unit-5: Surface preparation and paint application

Different steps involved in the preparation and chemical pre-treatment of surfaces, different application techniques, electrostatic spraying, electro-deposition, common paint defects and their prevention & cure.

References:

1. Organic Coating Technology, Vol. I & II; by HF Payne.
2. Outlines of Paint Technology; by WM Morgans.
3. Surface Coatings, Vol. I & II; by OCCA, Australia.
4. Basics of Paint Technology (Part I & II); by Malshe & Sikchi.
5. IS:33-.1992, IS:3493.1978, IS:74.1979, IS:101.1964, IS:2932, IS:2074

Title of the Course : SIMULATION MODELLING AND ANALYSIS OF MANUFACTURING SYSTEMS

Course Code : 24CMEC0MT

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.

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 2

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 3

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 4

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.

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

Unit 5

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

Reference Books:

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. **"Discrete - 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.

Title of the Course : COMPUTER CONTROL OF MANUFACTURING SYSTEMS

Course Code : 24CMEC0NT

Unit 1

Introduction to Computer integrated Manufacturing Systems: Manufacturing Systems, Types of Manufacturing Systems, Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems.

NC/ CNC Machine Tools: General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit, CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feed back Devices: Encoder, Resolver, Inductosyn, Tachometers, Counting devices, Digital to analog converters.

Unit 2

Interpolations: DDA integrators, simple and symmetrical DD reference word CNC interpolators. **Control loops for N C Systems:** Introduction-control loops for point and counting systems.

Constructional Features of CNC Machines: Design considerations of CNC machines for improving machining accuracy, Structural Members, Slide ways, bearings, Re-circulating ball Screws, Spindle drives, Work holding devices and tool holding devices, Automatic tool changers: Principles of Operation, Machining Centers, Tooling for CNC machines.

Unit 3

N.C part programming: Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming.

Computer Controls in NC: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control(DNC Systems): Configuration of DNC system, , Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC, Adaptive control machining systems. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control machining.

Unit 4

Industrial Robotics : Robotics technology : Types of Robots, Robot Technology Levels, Robot geometric configurations and Technical Features, basic robot motions, Robot control systems, robot drive systems, Work-cell control and Interlocks, robot sensors, robot safety, robot-computer interface, industrial robot applications and benefits, robot programming and programming languages

Unit 5

Computerized Manufacturing Planning and Control Systems: Computer aided process planning, Variant and Generative approaches, Computer integrated production planning and control systems, Typical production planning and control system, Material planning systems, Capacity planning, Shop Floor Control, Automatic identification, Automated data collection systems.

Prescribed Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, GROOVER M P, Prentice Hall India (P) Ltd,1989.
2. CAD/CAM Computer Aided Designand Manufacturing, Mikell P. Groover and Emory W. Zimmer Jr, Prentice Hall India (P) Ltd, 1992. (unit 1).
3. Computer Controls of Manufacturing Systems, M. Koren, Mc GrawHill, 1983.

Reference Books:

1. Numerical control of machine tools‖. Martin J.
2. CAD/CAM Principles and Applications P.N. Rao, Mc Grawhill 200.2
3. Numerical control of machine tools - Y. Koren & J. Benuri, Khanna, 1992.
4. Numerical control in manufacturing- Wilson, F.M Mc Graw Hill Newyork.
5. Theory and Design of CNC Systems, Suk-Hwan Suh, Seong-Kyoon Kang, Dea-Hyuk Chung and Ian Stroud, Springer,2008.

Title of the Course : ADVANCED MANUFACTURING TECHNIQUES

Course Code : 24CMEC0OT

Unit 1

Development and classification of non-conventional manufacturing processes, considerations in processes selection. Mechanics of material removal, tool design, effects of process parameters on MRR, accuracy and surface finish and applications of the various non-conventional machining processes.

Unit 2

Ultrasonic Machining (USM), abrasive & water jet machining (AJM), Electro Chemical Machines (ECM),. Electro Chemical Grinding (ECG), Chemical Machining (CHM), Electrical Discharge (EDM),Machining

Unit 3

Electron Beam Machining (EBM) and lon Beam machining (IBM) processes. High Energy Rate Forming Methods (HERF).

Unit 4

Electrochemical Grinding, Electrical-discharge Machining, Laser-beam Machining, Electron-beam Machining, Water-jet Machining, Abrasive-jet Machining.

Unit 5

Hybrid Machining Systems, Economics of Advanced Machining Processes, High Velocity Forming of Metals,Explosive forming, Electro-hydraulic forming, magnetic pulse forming, Application of HE RF Techniques.

Reference Books:

1. Pandey & Shan, Modern Machining Processes, Tara McGraw Hill, N.Delhi
2. P.K Mishra, Non Conventional Machining, Narosa Publishing House, N.Delhi
3. Amitabh Bhattacharya, New Technology, Institution of Engrs (I) Calcutta
4. ASTME, High Velocity Forming of Metals, PHI, N.Delhi
5. Ghosh &Mullick, Manufacturing Science, New Age publishers Pvt. Ltd. N. Delhi
6. Serope Kalpak Jain & Steven R. Schmid, Manufacturing Engineering & Technology, Addison Wesley Ltd.. N.Delhi

Title of the Course **:** Agile Manufacturing

Course Code : 24CMEC0PT

Unit 1

Introduction -Agile Manufacturing - Competitive environment of the future the business case for agile manufacturing conceptual frame work for agile manufacturing.

Unit 2

Four Core Concepts: Strategy driven approach - integrating organization, people technology interdisciplinary designmethodology.

Unit 3

Agile Manufacturing and Change Management: The change implications. Post failures in advanced manufacturing, changes on the way, traditional management accounting, paradigm, investment appraisal, product costing - performance, measurement and control systems, Traditional organization, control technological and design paradigms traditional problems in workplace- organizational issues - role of technology.

Unit 4

Agile Manufacturing Enterprise Design: Agile manufacturing - enterprise design, system concepts as the basic manufacturing theory - joint technical & organizational design and a model for the design of agile manufacturing enterprise, enterprise design process insights into design processes, what is interdisciplinary design, Main issues - simpledesign example.

Unit 5

Skill & Knowledge Enhancing Technologies for Agile Manufacturing: Skill and Knowledge enhancing Technologies - scheduling - technology design strategic-Design Concepts. Design and Skill of Knowledge enhancing Technologies for machine tool systems - Historical overview, Lessons, problems and Future development.

Reference Books:

1. Agile Manufacturing - Forging new Frontiers - Paul T. Kidd - Addison WesleyPublication -1994.
2. Agile Manufacturing –Dr. M.PChowdiah (Editor) – TataMcGraw Hill Publications - 1996.
3. On agile Manufacturing by M,P,Chowdaiah - Tata McGraw Hill Publications -1996.
4. Agile Manufacturing Systems by K Hans Raj -Alpha Science International Limited.