ANNAMACHARYA UNIVERSITY

(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT,
(UNIVERSITY LISTED IN UGC AS PER THE SECTION 2(f) OF THE UGC ACT, 1956)

RAJAMPET, YSR District, AP – 516126, INDIA

MECHANICAL ENGINEERING

Course Structure and Syllabi for Pre Ph.D.-Programme

SUBJECT-1

S. No	Course Code	Title of the Course
1	26CMEC0TT	Research Methodology for Engineers

SUBJECT-2

S. No	Course Code	Title of the Course
1	26CEEE0NT	Research and Publications ethics for Engineers

CORE SUBJECTS

Choose any Two subjects from the following list

S. No	Course Code	Title of the Course
1	26CMEC01T	Mechanics of Composite Materials
2	26CMEC02T	Experimental methods in Thermal engineering
3	26CMEC03T	Advanced Optimization Techniques
4	26CMEC04T	Nanomaterials Synthesis and Characterization Techniques
5	26CMEC05T	Intelligent Manufacturing Systems
6	26CMEC06T	Tribology and Bearing Design
7	26CMEC07T	Failure Analysis and Design
8	26CMEC08T	Finite Element Method
9	26CMEC09T	Dynamics and Mechanism Design
10	26CMEC0AT	Combustion Thermodynamics
11	26CMEC0BT	Phase change phenomena in fluids
12	26CMEC0CT	Solar thermal technologies and applications
13	26CMEC0DT	Thermal storage system
14	26CMEC0ET	Advanced Operations Management
15	26CMEC0FT	Tooling for Manufacture in Automation
16	26CMEC0GT	Design Of Experiments
17	26CMEC0HT	Industrial Design & Ergonomics
18	26CMEC0IT	Materials Characterization
19	26CMEC0JT	Advances In Materials and Processing
20	26CMEC0KT	Surface Treatment and Finishing
21	26CMEC0LT	Bio Material and Technology
22	26CMECOMT	Simulation Modelling and Analysis of Manufacturing Systems
23	26CMEC0NT	Computer Control of Manufacturing Systems
24	26CMEC0OT	Advanced Manufacturing Techniques
25	26CMEC0PT	Agile Manufacturing
26	26CMEC0QT	Advanced Material Science and Engineering process
27	26CMEC0RT	Technology of surface coatings
28	26CMEC0ST	Advanced Internal Combustion Engines

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Title of the Course	**:**	MECHANICS OF COMPOSITE MATERIALS
Course Code	**:**	26CMEC01T
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1 Introduce the types, classification, reinforcements and matrix materials of composites and their applications.
2 Explain the micromechanics of a unidirectional lamina and the estimation of its elastic properties.
3 Develop the stress-strain relations and coordinate transformations for an orthotropic lamina.
4 Explain the elastic behaviour and failure theories of unidirectional laminas and laminates.
5 Introduce the analysis of laminated composite plates and the major composite manufacturing methods.

Course Outcomes:

1 Classify composites and select suitable reinforcement and matrix combinations for given applications.
2 Estimate the elastic properties of a lamina using micromechanics.
3 Apply stress and strain transformations to evaluate off-axis stiffness and compliance of a lamina.
4 Analyze lamina and laminate strength using failure criteria, failure envelopes and first ply failure.
5 Analyze laminated plates using thin plate theory and select a suitable manufacturing process.

Unit 1 **9**

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 boron carbide fibres. Particulate composites, polymer composites, thermoplastics, thermosets, metal matrix and ceramic composites.

Unit 2 **9**

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 **10**

Coordinate transformations: Hooke's law for different types of materials, Hooke's law for a 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 **11**

Elastic behavior of unidirectional composites: Elastic constants of a lamina, relationship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

Strength of unidirectional lamina: Micromechanics 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 5 **9**

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

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

Prescribed Textbook:

1. **Mechanics of Composite Materials** - Robert M. Jones, McGraw-Hill Kogakusha Ltd, 1998.

Reference Books:

1. **Engineering Mechanics of Composite Materials** - Isaac M. Daniel and Ori Ishai, Oxford University Press, 1994.
2. **Analysis and Performance of Fibre Composites** - B.D. Agarwal and L.J. Broutman, Wiley-Interscience, New York, 1980.
3. **Mechanics of Composite Materials** - R.M. Jones, McGraw-Hill, New York, 1975.
4. **Analysis of Laminated Composite Structures** - L.R. Calcote, Van Nostrand Reinhold, New York, 1969.
5. **Introduction to Composite Materials** - Hull and Clyne, Cambridge University Press.
6. **Fiber Reinforced Composites** - P.K. Mallick, Marcel Dekker, Inc.
7. **Composite Materials Handbook** - Mel M. Schwartz, McGraw-Hill, 1984.

Title of the Course : EXPERIMENTAL METHODS IN THERMAL ENGINEERING
Course Code : 26CMEC02T
Course offered to : ME
Credits : 4

Course Objectives

1. Summarize the basic principles of measurement systems, experimental data processing, regression analysis, data acquisition techniques.
2. Comprehend the design of experimental facilities, dynamic response, modelling, simulation of measurement systems
3. Explain the working principles, construction, characteristics, and calibration of temperature and humidity measurement instruments.
4. Understand the principles and applications of instruments and techniques used for flow, velocity, and turbulence measurements
5. Explain the methods used for pressure, force, torque, and speed measurement, along with air pollution sampling and measurement techniques

Course Outcomes:

1. Apply measurement principles, experimental data analysis, regression techniques, and data acquisition methods to engineering problems.
2. Analyze the dynamic response of measurement systems and explain the design of experimental facilities using modelling and simulation techniques.
3. Evaluate suitable instruments for temperature and humidity measurement, including their calibration and dynamic characteristics.
4. Analyze appropriate instruments and techniques for measuring flow, velocity, and turbulence in engineering applications
5. Apply suitable methods for pressure, force, torque, and speed measurement and explain techniques for air pollution sampling and analysis

Unit 1 12

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 10

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 14

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 **10**

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 11

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.

Prescribed Textbook:

1. **Experimental Methods for Engineers -** J.P. Holman, McGraw-Hill Publications, ISBN-13: 978-0-07-352930-1 8th edition,2011

Reference Books:

1. **Mechanical Measurements -** Beckwith M.G., Marangoni R.D. and LienhardJ.H.,Pearson education india-publications, ISBN-13: 9789353945633,6th edition, 2020
2. **Measurement systems application and Design-** E.O.Doebelin,Tata McGraw- Hill, Publications, ISBN-13: 9780070616721, 5th edition 2009.

Title of the Course	:	ADVANCED OPTIMIZATION TECHNIQUES
Course Code	:	26CMEC03T
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Explain linear programming methods and the assignment problem with their applications.
2. Describe classical and numerical methods for unconstrained and constrained optimization.
3. Explain the principles and operators of genetic algorithms and their use in constrained optimization.
4. Introduce genetic programming and multi-objective genetic algorithms with Pareto analysis.
5. Illustrate the application of optimization to design and manufacturing problems.

Course Outcomes:

1. Formulate and solve linear programming and assignment problems.
2. Apply classical and numerical methods to constrained and unconstrained optimization problems.
3. Apply genetic algorithms to engineering optimization problems, including constrained cases.
4. Develop genetic programming and multi-objective GA solutions using Pareto-optimal fronts.
5. Formulate and solve optimization models for mechanisms, structural members, machining and welding.

Unit 1 **10**

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

Assignment problem: Hungarian algorithm, degeneracy, applications, unbalanced problems, travelling salesman problem.

Unit 2 **10**

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 simplex search method, gradient of a function, steepest descent method, Newton's method, types of penalty methods for handling constraints.

Unit 3 **9**

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, drawbacks of GA.

Unit 4 **10**

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

Multi-objective GA: Pareto analysis, non-dominated front, multi-objective GA, non-dominated sorted GA, convergence criterion, applications of multi-objective problems.

Unit 5 **9**

Applications of optimization in design and manufacturing systems: Typical applications such as optimization of path synthesis of a four-bar mechanism, minimization of weight of a cantilever beam, optimization of springs and gears, general optimization model of a machining process, optimization of arc welding parameters, and general procedure in optimizing machining operations sequence.

Prescribed Text Books:

1. **Introduction to Optimum Design** - Jasbir S. Arora, McGraw-Hill (International).
2. **Optimization for Engineering Design** - Kalyanmoy Deb, PHI Learning.

Reference Books:

1. **Genetic Algorithms in Search, Optimization, and Machine Learning** - D.E. Goldberg, Addison-Wesley.
2. **Genetic Programming** - John R. Koza, MIT Press.
3. **Multi-Objective Optimization Using Evolutionary Algorithms** - Kalyanmoy Deb, Wiley / PHI.

Title of the Course	:	NANOMATERIALS SYNTHESIS AND CHARACTERIZATION TECHNIQUES
Course Code	:	26CMEC04T
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Introduce nanomaterial classes, size effects and the general methods of nanostructure synthesis.
2. Explain physico-chemical and gas-phase synthesis routes for nanostructured materials.
3. Explain the thermodynamics of nucleation and growth and the control of particle size and morphology.
4. Describe the magnetic, electronic and optoelectronic properties of nanoscale materials.
5. Explain the principles of X-ray, electron microscopy, spectroscopy and scanning probe techniques for characterizing nanophase materials.

Course Outcomes:

1. Classify nanomaterials, explain size-dependent effects and choose a scalable synthesis method.
2. Evaluate a suitable physico-chemical or gas-phase route for a given nanomaterial.
3. Analyze nucleation, growth, aggregation and colloidal stability to control size and morphology.
4. Relate the magnetic, electronic and optical properties of nanomaterials to size and structure.
5. Interpret data from XRD, SEM/TEM and spectroscopic techniques for nanophase materials.

Unit 1 **9**

Nanomaterials: 0D, 1D and 2D structures; size effects; fraction of surface atoms; specific surface energy and surface stress; effect on the lattice parameter; phonon density of states. General methods for the synthesis of nanostructures: precipitative, reactive, hydrothermal/solvothermal methods; suitability of such methods for scaling; potential uses.

Unit 2 **10**

Physico-chemical methods of nanostructured materials: Solution growth techniques of 1D-2D nanostructures: 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 **10**

Specific features of nanoscale growth: Thermodynamics of phase transitions; triggering the phase transition; fundamentals of nucleation and growth; controlling nucleation and 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; nanoparticle morphology.

Unit 4 **10**

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 **9**

Characterization of nanophase materials: Fundamentals of the techniques, experimental approaches and data interpretation. X-ray characterization: applications and limitations, X-ray sources, wide-angle and extended X-ray absorption techniques. 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.

Prescribed Text Books:

1. **Guozhong Cao and Ying Wang**, *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, 2nd ed., World Scientific, 2011
2. **T. Pradeep**, *NANO: The Essentials – Understanding Nanoscience and Nanotechnology*, McGraw-Hill Education (India), 2007

Reference Books:

1. **The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Vol. 1** - C.N.R. Rao, A. Müller and A.K. Cheetham, Wiley-VCH Verlag GmbH, Germany, 2004.
2. **Nanomaterials and Nanochemistry** - C. Bréchignac, P. Houdy and M. Lahmani, Springer, Berlin Heidelberg, Germany, 2006.
3. **Nanostructures and Nanomaterials: Synthesis, Properties and Applications** - Guozhong Cao, World Scientific Publishing, Singapore, 2004.
4. **Characterization of Nanophase Materials** - Zhong Lin Wang, Wiley-VCH Verlag GmbH, Germany, 2004.
5. **Nanostructured Materials: Processing, Properties and Potential Applications** - Carl C. Koch, Noyes Publications / William Andrew Publishing, Norwich, New York, USA, 2002.

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Title of the Course	**:**	INTELLIGENT MANUFACTURING SYSTEMS
Course Code	**:**	26CMEC05T
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the structure of CIM systems, manufacturing communication systems and the architecture of intelligent manufacturing.
2. Describe the components of knowledge-based systems, machine learning concepts and artificial neural networks.
3. Explain variant and generative approaches to automated process planning and the role of expert systems.
4. Introduce knowledge-based systems for manufacturing equipment selection.
5. Explain group technology models and algorithms and their knowledge-based extensions.

Course Outcomes:

1. Describe the functional areas of CIM and the architecture and data flow of an intelligent manufacturing system.
2. Apply knowledge representation and neural network concepts to manufacturing problems.
3. Develop variant and generative process plans, including expert system based planning.
4. Model and solve the equipment selection problem using a knowledge-based system.
5. Apply group technology clustering algorithms to form part families and machine cells.

Unit 1 **10**

Computer Integrated Manufacturing Systems: Structure and functional areas of a 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 **10**

Components of knowledge-based systems: Basic components of knowledge-based systems, knowledge representation, comparison of knowledge representation schemes, inference 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 **9**

Automated process planning: Variant approach, generative approach, expert systems for process planning, feature recognition, phases of process planning.

Unit 4 **9**

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 **10**

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 systems, structure of a knowledge-based system for group technology (KBSGT): database, knowledge base, clustering algorithm.

Prescribed Text Books:

1. **Mikell P. Groover**, *Automation, Production Systems, and Computer-Integrated Manufacturing*, 5th ed., Pearson, 2016
2. **Simon Haykin**, *Neural Networks and Learning Machines*, 3rd ed., Pearson, 2009

Reference Books:

1. **Intelligent Manufacturing Systems** - Andrew Kusiak, Prentice Hall.
2. **Artificial Neural Networks** - B. Yegnanarayana, PHI Learning.
3. **Automation, Production Systems and Computer-Integrated Manufacturing** - M.P. Groover, Pearson.
4. **Neural Computing: Theory and Practice** - Philip D. Wasserman, Van Nostrand Reinhold.

Title of the Course	**:**	TRIBOLOGY AND BEARING DESIGN
Course Code	**:**	26CMEC06T
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce friction, wear, lubrication regimes and the viscous flow fundamentals used in bearing analysis.
2. Explain pressure development in hydrodynamic lubrication and derive Reynolds equation for slider bearings.
3. Analyze idealized full, short and partial journal bearings and the significance of the Sommerfeld number.
4. Describe the selection and life estimation of antifriction bearings and the working of porous and gas bearings.
5. Introduce active magnetic bearings and magneto-hydrodynamic bearings.

Course Outcomes:

1. Characterize friction and wear and identify the lubrication regime for a given contact.
2. Apply Reynolds equation to estimate load capacity and centre of pressure of slider bearings.
3. Evaluate the performance of journal bearings using Sommerfeld number and end-leakage effects.
4. Select antifriction bearings based on load, life and probability of survival, and explain fretting.
5. Explain the working principles, merits and limitations of magnetic and porous bearings.

Unit 1 **10**

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-Poiseuille theory, viscometers. Numerical problems. Concept of lightly loaded bearings, Petroff's equation, numerical problems.

Unit 2 **10**

Hydrodynamic lubrication: Pressure development mechanism. Converging and diverging films and pressure-induced flow. Reynolds equation in two dimensions with assumptions. Introduction to idealized slide bearing with fixed shoe and pivoted shoes. Expression for load carrying capacity. Location of centre of pressure, effect of end leakage on performance. Numerical problems.

Unit 3 **10**

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 **9**

Antifriction bearings: Advantages, selection, nominal life, static and dynamic load carrying 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 principle. Fretting phenomenon and its stages.

Unit 5 **9**

Magnetic bearings: Introduction to magnetic bearings, active magnetic bearings. Different equations used in magnetic bearings and working principle. Advantages and disadvantages of magnetic bearings, electrical analogy, magneto-hydrodynamic bearings.

Prescribed Text Books:

1. **Introduction to Tribology of Bearings** - B.C. Majumdar, Wheeler Publishing, New Delhi, 2001.
2. **Lubrication of Bearings: Theoretical Principles and Design** - Radzimovsky, Oxford Press Company, 2000.

Reference Books:

1. **Theory and Practice of Lubrication for Engineers** - Dudley D. Fuller, John Wiley & Sons, New York.
2. **Principles and Applications of Tribology** - D.F. Moore, Pergamon Press, 1975.
3. **Theory of Hydrodynamic Lubrication** - Oscar Pinkus and Beno Sternlicht, McGraw-Hill, 1961.
4. **Engineering Tribology** - G.W. Stachowiak and A.W. Batchelor, Elsevier, 1993.
5. **Hydrostatic and Hybrid Bearing Design** - W.B. Rowe, Butterworths, 1983.
6. **Hydrostatic Bearings for Machine Tools and Similar Applications** - F.M. Stansfield, Machinery Publishing, 1970.

Title of the Course	**:**	FAILURE ANALYSIS AND DESIGN
Course Code	**:**	26CMEC07T
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the role of failure prevention analysis in design and the common modes of mechanical failure.
2. Introduce the fundamentals of linear elastic and elastic-plastic fracture mechanics.
3. Describe high-cycle fatigue behaviour, S-N-P curves and multiaxial fatigue theories.
4. Explain cumulative damage, life prediction, low-cycle fatigue and creep behaviour of materials.
5. Describe fretting, wear and corrosion mechanisms and the methods to minimize them.

Course Outcomes:

1. Identify failure modes in mechanical components and apply failure prevention principles in design.
2. Apply fracture mechanics concepts to assess crack-containing components.
3. Estimate fatigue life under high-cycle and multiaxial loading using S-N-P curves and design factors.
4. Predict life under cumulative damage, low-cycle fatigue and creep using standard theories.
5. Diagnose fretting, wear and corrosion failures and recommend preventive measures.

Unit 1 **9**

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 in design, elastic-plastic fracture mechanics.

Unit 2 **10**

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 **9**

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 **11**

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 and multiaxial states of stress, cumulative creep concept, combined creep and fatigue.

Unit 5 **9**

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 Textbook:

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	**:**	26CMEC08T
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce the fundamentals of FEM: variational and weighted residual formulations, convergence and element equations.
2. Develop finite element formulations for one-dimensional bar, truss, beam and heat transfer elements.
3. Develop formulations for two-dimensional plane elasticity and axisymmetric elements.
4. Introduce three-dimensional solid elements and higher-order shape functions.
5. Explain the formulation of mass matrices and the solution of eigenvalue problems for dynamic analysis.

Course Outcomes:

1. Derive element equations using potential energy and weighted residual methods.
2. Formulate and solve bar, truss, beam and one-dimensional heat transfer problems using FEM.
3. Analyze plane stress, plane strain and axisymmetric problems using triangular and quadrilateral elements.
4. Select suitable three-dimensional and higher-order elements for solid mechanics problems.
5. Perform free vibration analysis of bars, stepped bars and beams using consistent and lumped mass matrices.

Unit 1 **8**

Introduction to finite element method: Engineering analysis, convergence criteria, variational 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 **12**

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 **12**

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 strain 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 **8**

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 **8**

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 eigenvalues and eigenvectors, applications to bars, stepped bars and beams.

Prescribed Text Books:

1. **Finite Elements Analysis: Procedures in Engineering** - H.V. Lakshminarayana, Universities Press, 2004.
2. **Finite Elements Method in Engineering** - S.S. Rao, 4th Edition, Elsevier, 2006.

Reference Books:

1. **Daryl L. Logan**, *A First Course in the Finite Element Method*, 6th ed., Cengage Learning, 2016
2. **Tirupathi R. Chandrupatla and Ashok D. Belegundu**, *Introduction to Finite Elements in Engineering*, 4th ed., Pearson, 2012
3. **J.N. Reddy**, *An Introduction to the Finite Element Method*, 3rd ed., McGraw-Hill, 2006

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Title of the Course	:	DYNAMICS AND MECHANISM DESIGN
Course Code	:	26CMEC09T
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Explain the geometry of motion, mobility and kinematic analysis of plane mechanisms.
2. Introduce generalized principles of dynamics, including virtual work and Lagrange and Hamilton formulations.
3. Explain type, number and dimensional synthesis of linkages and motion generation.
4. Describe graphical and analytical methods of dimensional synthesis of mechanisms.
5. Introduce system dynamics, gyroscopic action and the analysis of spatial mechanisms.

Course Outcomes:

1. Determine mobility and perform kinematic analysis of plane mechanisms using standard methods.
2. Derive equations of motion of mechanical systems using Lagrange's and Hamilton's formulations.
3. Synthesize linkages for function, path and motion generation with precision positions.
4. Design four-bar and slider-crank mechanisms using graphical and analytical methods such as Freudenstein's equation.
5. Analyze gyroscopic effects, phase plane response and position, velocity and acceleration of spatial mechanisms.

Unit 1 **10**

Geometry of motion: Introduction, analysis and synthesis, mechanism terminology, planar, spherical and spatial mechanisms, mobility, Grashof's law, equivalent mechanisms, unique mechanisms.

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

Unit 2 **10**

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 principle, examples, Hamilton's equations, Hamilton's principle, Lagrange's equation from Hamilton's principle, derivation of Hamilton's equations. Numerical examples.

Unit 3 **9**

Synthesis of linkages: Type, number and dimensional synthesis, function generation, path generation and body guidance, precision positions, structural error, Chebyshev 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 **10**

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.

Analytical 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 **9**

System dynamics: Gyroscopic action in machines, Euler's equation of motion, phase plane representation, phase plane analysis, response of linear systems to transient disturbances.

Spatial mechanisms: Introduction, position analysis problem, velocity and acceleration analysis, Eulerian angles. Numerical examples.

Prescribed Text Books:

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

Reference Books:

1. **Theory of Machines and Mechanisms** - J.E. Shigley, McGraw-Hill, 1995.
2. **Mechanism and Machine Theory** - A.G. Ambekar, PHI, 2007.
3. **Theory of Mechanisms and Machines** - A. Ghosh and A.K. Mallik, East-West Press.

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	COMBUSTION THERMODYNAMICS
Course Code	**:**	26CMEC0AT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. impart knowledge of thermodynamic principles, fuel properties, combustion reactions, and energy analysis of reacting systems.
2. explain the concepts of chemical equilibrium, Gibbs free energy, and equilibrium composition of combustion reactions.
3. Comprehend the combustion chemistry, reaction kinetics, conservation equations, and transport phenomena.
4. familiarize with premixed and diffusion flames, burning velocity, ignition, flame stabilization, and flame extinction.
5. provide knowledge of liquid and solid fuel combustion, spray combustion, combustion emissions, and emission control techniques

Course Outcomes:

1. Apply thermodynamic principles to analyze reacting systems, fuel properties, combustion reactions, and flame temperature.
2. Analyze chemical equilibrium using Gibbs free energy, equilibrium constants, and equilibrium composition of reacting systems.
3. Explain combustion reaction kinetics, reaction mechanisms, conservation equations, and transport phenomena in combustion systems.
4. Analyze premixed flame characteristics, burning velocity, ignition, flame extinction, and flame stabilization under laminar and turbulent conditions.
5. Evaluate diffusion flames, liquid and solid fuel combustion processes, and emission control methods for reducing environmental pollution

Unit 1 14

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 10

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 11

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 **10**

. **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 12

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 Textbook:

1.Introduction to Combustion by Mishra, D.P., Prentice Hall, 2009, ISBN 9788120333482

2.Fuels and Combustion by Sharma, S. P. , Tata McGraw Hill, New Delhi, 2001 ISBN: 9780070966277.

Reference Books:

1.Thermodynamics: An Engineering Approach by Çengel, Yunus A., Boles, Michael A., and Kanoğlu, .Mehmet, 10th Edition, McGraw Hill, 2025 Indian edition. ISBN: 978-93-6444-020-2.

2.Modern Engineering Thermodynamics by Balmer, Robert T., , 1st Edition, Academic Press/Elsevier, 2011.

3.Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw Hill, ISBN: 9780070682931

4. Principles of Combustion, Kuo K. K., John Wiley and Sons , 3rd Edition, 2024. ISBN: 978-1-394-18706-5.

5.An Introduction to Combustion concepts and application by Stephen R. Turns, McGraw Hill Higher Education, 4th Edition, 2021. ISBN: 978-1-260-57769-4 .

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	Phase change phenomena in fluids
Course Code	**:**	26CMEC0BT
Course offered to :		ME
Credits	**:**	4

Course Objectives

1. Familiarize with the fundamentals of thermodynamic equilibrium, fugacity, Gibbs phase rule, and phase equilibrium of binary and multicomponent mixtures.
2. understand the principles of pool boiling, different boiling regimes, and heat transfer enhancement techniques.
3. Summarize the mechanisms of flow boiling in horizontal and vertical tubes, including different boiling regimes and heat transfer augmentation techniques.
4. Comprehend the two-phase flow patterns, bubble dynamics, nucleation mechanisms, and flow instabilities in boiling systems.
5. Summarize the filmwise and dropwise condensation, condensation heat transfer

Course Outcomes:

1. Explain thermodynamic equilibrium, fugacity, Gibbs phase rule, and phase equilibrium diagrams for binary and multicomponent mixtures.
2. Analyze pool boiling regimes and solve numerical problems related to nucleate boiling and heat transfer enhancement.
3. Analyze flow boiling mechanisms and regimes in horizontal and vertical tubes and evaluate heat transfer augmentation techniques
4. Analyze two-phase flow patterns, bubble dynamics, nucleation, and flow instabilities using relevant equations
5. Analyze filmwise and dropwise condensation processes and solve numerical problems related to condensation heat transfer

Unit 1 12

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 9

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 10

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 **11**

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 10

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

Prescribed Textbook:

1. Convective boiling and condensation by John G. Collier and John R. Thome, Third edition, Oxford Science Publication, 1994, ISBN- 9780198562825
2. Boiling heat transfer and Multiphase flow by L.S Tong, Second edition, Taylor and Francis Publication, 1997, ISBN-9781560324850

Reference Books:

1.Fundamentals of Multiphase Flows by Christopher E. Brennen, Cambridge University Press 2005First edition, Cambridge University Press, ISBN-978-0-521-84804-6

Title of the Course	**:**	SOLAR THERMAL TECHNOLOGIES AND ITS APPLICATIONS
Course Code	**:**	26CMEC0CT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the principles of solar radiation, solar geometry, solar time, and the measurement of solar radiation.
2. Comprehend the performance of flat plate collectors, evacuated tube collectors, and concentrating solar collectors.
3. Understand the principles and performance of sensible, latent, and thermochemical thermal energy storage systems.
4. Summarize the design, working principles, and applications of solar thermal energy systems for heating, cooling, power generation, drying, cooking, and desalination.
5. Familiarize students with recent developments in thermal energy storage materials and solar thermal technologies.

Course Outcomes:

1. Calculate solar radiation, solar angles, sunrise and sunset times, and solar radiation incident on inclined surfaces.
2. Analyze the thermal performance and efficiency of flat plate and evacuated tube solar collectors.
3. Evaluate the performance, orientation, and tracking requirements of concentrating solar collectors.
4. Analyze sensible, latent, and thermochemical thermal energy storage systems and their performance.
5. Assess solar thermal applications and recent advancements in thermal energy storage materials and systems

Unit 1 13

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 11

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 12

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 **10**

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 11

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 Textbook:

1. Solar Energy: Principles of Thermal Collection and Storage, by S. P. Sukhatme and J. K. Nayak4th edition-2017, McGraw Hill Education (India)-publisher, ISBN-13: 9789352607112
2. Non-Conventional Energy Sources by G. D. Rai, 6th edition, 2025, Khanna Publishers, ISBN-13: 978817409073

Reference Books:

1. **John A. Duffie and William A. Beckman**, *Solar Engineering of Thermal Processes*, 4th ed., Wiley, 2013
2. **Soteris A. Kalogirou**, *Solar Energy Engineering: Processes and Systems*, 2nd ed., Academic Press (Elsevier), 2014
3. **H.P. Garg and J. Prakash**, *Solar Energy: Fundamentals and Applications*, Tata McGraw-Hill, 2000
4. **Ibrahim Dincer and Marc A. Rosen**, *Thermal Energy Storage: Systems and Applications*, 2nd ed., Wiley, 2011

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	THERMAL STORAGE SYSTEM
Course Code	**:**	26CMEC0DT
Course offered to :		ME
Credits	**:**	4

Course Objectives

1. Summarize the fundamental concepts of energy storage, the need for thermal energy storage, and methods for improving heat transfer.
2. Familiarize students with sensible heat storage technologies, their modeling, and thermal storage using solids, liquids, and underground reservoirs.
3. Comprehend the regenerator configurations and the factors influencing their steady-state and transient performance.
4. Provide knowledge of latent heat storage, phase change materials, and mathematical models used in thermal storage system design.
5. Familiarize students with the integration of thermal energy storage in renewable energy systems, industrial processes, and energy conservation application

Course Outcomes:

1. Explain energy storage technologies and justify the selection of suitable thermal storage methods for specific applications.
2. Analyze sensible heat storage systems using appropriate thermal models and storage parameters.
3. Evaluate the steady-state and transient performance of parallel-flow and counter-flow regenerators under varying operating conditions.
4. Apply enthalpy-based modeling and phase change principles to evaluate latent heat storage systems and select suitable PCMs.
5. Assess the suitability of thermal energy storage systems for solar energy utilization, waste heat recovery, refrigeration, food preservation, and industrial heating applications.

Unit 1 10

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 12

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 13

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 **12**

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 11

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 Textbook:

1. Thermal Energy Storage and Regeneration by F. W. Schmidt and A.J. Willimot, hemisphere Publishing Corporation, 1981, ISBN: 978-0-07-055346-0.
2. Thermal Energy Storage: Systems and Applications by Ibrahim Dincer and Marc A. Rosen, 3rd Edition, John Wiley & Sons, 2021, ISBN: 978-1-119-71315-9.

Reference Books:

1. Heat Transfer in Cold Climates by Virgil J. Lunardini, Van Nostrand Reinhold Company, New York, 1981, 731 pages. ISBN: 978-0-442-26250-1.

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	ADVANCED OPERATIONS MANAGEMENT
Course Code	**:**	26CMEC0ET
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain product design, concurrent engineering, value engineering and aggregate planning strategies.
2. Describe push and pull inventory control systems, including MRP, MRP-II, JIT and Kanban.
3. Explain scheduling techniques, project management using PERT/CPM and financial project appraisal.
4. Introduce the philosophy, tools and techniques of Total Quality Management.
5. Explain quality systems, ISO 9000, quality costs and the tools used to implement TQM.

Course Outcomes:

1. Apply value engineering and aggregate planning models to product and capacity decisions.
2. Plan material requirements using MRP and design Kanban-based JIT systems.
3. Develop job shop schedules, analyze projects using PERT/CPM and appraise investments financially.
4. Apply TQM tools, QFD and benchmarking to quality improvement problems.
5. Evaluate quality systems and implement Kaizen, 5S, poka-yoke, Taguchi and Six Sigma methods.

Unit 1 **11**

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 and cost, product life cycle, steps in value engineering, methodology in value engineering, FAST diagram, matrix method.

Aggregate planning: Definition, different strategies, various models of aggregate planning: transportation and graphical models.

Unit 2 **10**

Advanced inventory control systems: Push systems: material requirement planning (MRP), 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 versus push systems: Just-in-Time (JIT) philosophy, Kanban system, calculation of number of Kanbans, requirements for implementation of JIT, JIT production process, benefits of JIT.

Unit 3 **11**

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: Programme Evaluation and Review Technique (PERT), three-time 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 **7**

Total quality management: Philosophy of TQM, quality gurus, QC tools, quality circles, benchmarking, strategic quality planning, quality function deployment.

Unit 5 **9**

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, poka-yoke, Taguchi method, Six Sigma management: models and case studies. Reverse engineering: philosophies and case studies.

Prescribed Text Books:

1. **William J. Stevenson**, *Operations Management*, 13th ed., McGraw-Hill Education, 2018 (Indian adaptation also available)
2. **Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield and Mary Besterfield-Sacre**, *Total Quality Management*, 3rd ed. (Indian reprint by Pearson), 2011

Reference Books:

1. **Total Quality Management** - J.E. Rose, Kogan Page Ltd., 1993.
2. **Operations Management** - E.S. Buffa, C.B. Publishers.
3. **Operations Management: Theory and Problems** - Joseph G. Monks, McGraw-Hill Book Company, Kogakusha.
4. **Production Systems Management** - James L. Riggs, John Wiley & Sons Inc.
5. **Production and Operations Management** - S.N. Chary, Tata McGraw-Hill.
6. **Operations Management** - Chase, McGraw-Hill.
7. **Production and Operations Management** - R. Panneerselvam, PHI.
8. **Production and Operations Analysis** - Steven Nahmias.

Title of the Course	**:**	TOOLING FOR MANUFACTURE IN AUTOMATION
Course Code	**:**	26CMEC0FT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the mechanics of metal cutting, modern cutting tool materials and cutting tool geometry.
2. Explain machining optimization and the tooling requirements of CNC machines.
3. Describe the principles of location and clamping and the design of fixtures.
4. Explain fixturing for automation and flexible manufacturing systems.
5. Introduce plastics as tooling materials.

Course Outcomes:

1. Analyze cutting forces and chip formation, and select cutting tool materials and geometry.
2. Optimize machining parameters and select tool holding systems, magazines and tool changers for CNC machines.
3. Design locating and clamping schemes and select suitable fixtures for a given operation.
4. Select pallet-based and modular fixturing systems for automated and FMS environments.
5. Design simple plastic and urethane based tooling and compute the required forces.

Unit 1 **12**

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 and 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, wiper geometry, insert clamping methods, tool angles, threading tools, cutters.

Unit 2 **10**

Optimization: Machining cost and production rate versus 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 holder-spindle 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 **10**

Location and clamping methods: Basic principles of locating, locating methods and devices, basic principles of clamping, clamping methods.

Fixtures: Definitions, general considerations, machine considerations, process considerations, product considerations, types of fixtures, vise fixtures, milling fixtures.

Unit 4 **8**

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 systems: T-slot based, dowel pin based, fixturing components.

Unit 5 **8**

Plastics for tooling materials: Introduction, commonly used plastics for tooling, epoxy plastic tools, construction methods, urethane dies, force calculation for urethane pressure pads.

Prescribed Text Books:

1. **Tool Design** - Cyril Donaldson, Tata McGraw-Hill, India.
2. **Fundamentals of Tool Design** - Edward G. Hoffman, SME, USA.

Reference Books:

1. **Handbook of Jigs and Fixtures Design** - William E. Boyes, SME, USA.
2. **Tool Engineering and Design** - G.R. Nagpal, Khanna Publications.
3. **Metal Cutting Theory and Practice, 2nd Edition** - David A. Stephenson and John S. Agapiou, CRC Press / Taylor and Francis.
4. **Metal Cutting and Tool Design** - B.J. Ranganath, Vikas Publishing House.
5. **Die Design Handbook** - ASTME, McGraw-Hill.

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	DESIGN OF EXPERIMENTS
Course Code	**:**	26CMEC0GT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the strategy of experimentation, basic principles of design of experiments and basic statistical concepts.
2. Describe regression models, parameter estimation and hypothesis testing.
3. Explain full and fractional factorial designs and the development of mathematical models.
4. Introduce the Taguchi method: orthogonal arrays, quality loss function and signal-to-noise ratio.
5. Explain one-way and two-way analysis of variance and its use with factorial and Taguchi designs.

Course Outcomes:

1. Plan experiments using DOE principles and summarize data using descriptive statistics.
2. Fit and validate regression models, including hypothesis tests and lack-of-fit testing.
3. Design and analyze full and fractional factorial experiments and develop mathematical models.
4. Apply Taguchi orthogonal arrays and signal-to-noise ratios for parameter optimization.
5. Perform ANOVA and interpret the results of factorial and Taguchi experiments.

Unit 1 **8**

Introduction: Brief introduction of optimization techniques, strategy of experimentation, basic principles of design, terminology used in design of experiments, guidelines for designing experiments. Basic statistical concepts: types of data, graphical representation of data, measures of central tendency and dispersion, skewness.

Unit 2 **10**

Fitting regression models: Introduction, linear regression models, estimation of parameters in linear regression models, the method of least squares. Hypothesis testing: null hypothesis, alternative hypothesis. Prediction of new response observations, testing for lack of fit.

Unit 3 **10**

Factorial design: Basic definition and principles, advantages of factorials, types of factorial design: full factorial design and fractional factorial design, design matrix, development of mathematical model, regression model diagnostics.

Unit 4 **10**

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 **10**

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.

Prescribed Textbooks:

1. **Ranjit K. Roy**, *Design of Experiments Using the Taguchi Approach: 16 Steps to Product and Process Improvement*, Wiley, 2001

2. **Douglas C. Montgomery and George C. Runger**, *Applied Statistics and Probability for Engineers*, 7th ed., Wiley, 2018 (Indian adaptation available)

Reference Books:

1. **Design and Analysis of Experiments** - D.C. Montgomery, John Wiley.
2. **Statistical Design and Analysis of Experiments** - Peter W.M. John, Macmillan.
3. **Statistical Methods for Engineering and Sciences** - H.C. Taneja, I.K. International Publishing House Pvt. Ltd.
4. **Statistical Analysis for Engineers and Scientists** - J. Wesley Barnes, McGraw-Hill Inc.

Title of the Course	**:**	INDUSTRIAL DESIGN AND ERGONOMICS
Course Code	**:**	26CMEC0HT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce the approach to industrial design, the man-machine relationship and workstation design.
2. Explain the design of controls and displays for machines, vehicles and products.
3. Explain ergonomics in product design and automated systems, and the use of anthropometric data.
4. Describe the visual effects of line, form and colour in engineering equipment.
5. Explain aesthetic concepts, style and the practice of industrial design.

Course Outcomes:

1. Apply ergonomic principles to workstation and working-position design.
2. Design suitable controls, displays, furniture and instruments for user needs.
3. Use anthropometric data and computerized databases in ergonomic product design.
4. Select line, form and colour for engineering equipment using principles of visual perception.
5. Evaluate aesthetic and style aspects of products within the industrial design process.

Unit 1 **10**

Introduction: An approach to industrial design, elements of design structure for industrial design in engineering applications in modern manufacturing systems.

Ergonomics and industrial design: Introduction, general approach to the man-machine relationship, workstation design, working position.

Unit 2 **10**

Controls and displays: Shapes and sizes of various controls and displays, multiple displays and control situations, design of major controls in automobiles, machine tools etc., design of furniture, design of instruments.

Unit 3 **10**

Ergonomics and production: Ergonomics and product design, ergonomics in automated systems, expert systems for ergonomic design, anthropometric data and its applications in ergonomic design, limitations of anthropometric data, use of computerized database.

Unit 4 **9**

Visual effects of line and form: The mechanics of seeing, psychology of seeing, general influences of line 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 **9**

Aesthetic concepts: Concept of unity, concept of order with variety, concept of purpose, style and environment, aesthetic expressions. Style: components of style, house style, observations on style in capital goods.

Industrial design in practice: General design, specifying design equipment, rating the importance of industrial design, industrial design in the design process.

Prescribed Text Books:

1. **Industrial Design for Engineers** - W.H. Mayall, Iliffe Books Ltd., London.
2. **Applied Ergonomics Handbook** - Brian Shackel (Ed.), Butterworth Scientific.

Reference Books:

1. **Mark S. Sanders and Ernest J. McCormick**, *Human Factors in Engineering and Design*, 7th ed., McGraw-Hill, 1993
2. **Martin Helander**, *A Guide to Human Factors and Ergonomics*, 2nd ed., CRC Press (Taylor & Francis), 2005
3. **Stephen Pheasant and Christine M. Haslegrave**, *Bodyspace: Anthropometry, Ergonomics and the Design of Work*, 3rd ed., CRC Press, 2006
4. **Kroemer, Kroemer and Kroemer-Elbert**, *Ergonomics: How to Design for Ease and Efficiency*, 2nd ed., Prentice Hall, 2001

Title of the Course	:	MATERIALS CHARACTERIZATION
Course Code	:	26CMEC0IT
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Explain X-ray diffraction and X-ray photoelectron spectroscopy for structural and surface characterization.
2. Describe electron microscopy and atomic force microscopy techniques.
3. Explain optical, vibrational and atomic spectroscopic techniques and dynamic light scattering.
4. Describe thermal analysis methods: TGA, DTA and DSC.
5. Explain potentiometric and voltammetric electroanalytical methods.

Course Outcomes:

1. Interpret XRD patterns and estimate crystallite size and strain using the Debye-Scherrer equation.
2. Select and interpret SEM, TEM, SAED and AFM for microstructural characterization.
3. Apply UV-Vis, FTIR, Raman, DLS, AAS and ICP techniques for material and composition analysis.
4. Analyze the thermal behaviour of materials using TGA, DTA and DSC.
5. Interpret cyclic voltammetry and related electrochemical data.

Unit 1 **10**

X-ray based characterization: Principles and applications of X-ray diffraction, powder (polycrystalline) and single-crystal 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 **10**

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 **12**

UV-Vis and IR spectrophotometry: UV-Vis spectrophotometers: principles, operation and application for band gap measurements. IR/FTIR spectrophotometers: principles, sample preparation, operation and application.

Raman, light scattering and atomic spectroscopy: Raman spectroscopy: principles and applications. Optical microscope; nanoparticle size measurement by dynamic light scattering method. Atomic absorption spectroscopy: principle, instrumentation, advantages and

disadvantages of AAS, applications. Inductively coupled plasma spectroscopy: instrumentation, principle and applications.

Unit 4 **8**

Thermal methods: Principle, instrumentation and working of thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC).

Unit 5 **8**

Potentiometry and voltammetry: Types of electrodes, reference and indicator electrodes, glass electrode, ion-selective electrodes. Voltammetric principles, stripping voltammetry, cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis, linear sweep voltammetry, chronoamperometry.

Prescribed Text Books:

1. B.D. Cullity and S.R. Stock, *Elements of X-ray Diffraction*, 3rd ed., Pearson, 2001

2. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, *Principles of Instrumental Analysis*, 7th ed., Cengage, 2017

Reference Books:

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

Title of the Course	**:**	ADVANCES IN MATERIALS AND PROCESSING
Course Code	**:**	26CMEC0JT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Classify engineering materials and explain atomic structure, bonding, defects and strengthening mechanisms.
2. Describe ferrous and non-ferrous alloys, their heat treatment and applications.
3. Explain the structure, properties and processing of polymers and ceramics.
4. Explain the classification, constituents, production and properties of composite materials.
5. Introduce advanced processing techniques such as thermal spraying, ion beam machining and diamond coating.

Course Outcomes:

1. Relate structure, defects and strengthening mechanisms to the mechanical behaviour of metals.
2. Select ferrous and non-ferrous alloys and suitable heat treatments for given applications.
3. Select suitable polymers and ceramics and their processing routes.
4. Evaluate the properties of fibre-reinforced, metal matrix and ceramic matrix composites.
5. Explain advanced processing and coating techniques used for tribological applications.

Unit 1 **10**

Classification and characteristics: Metals: ferrous and non-ferrous metals and their classification; types of ceramics, polymers and composites and classification of composites.

General properties and structure: Atoms, molecules, bonds in solids, crystalline structure, defects in metallic structure, dislocations and plastic deformation. Strengthening mechanisms: grain size, dislocation, cold work, precipitation hardening, dispersion hardening, phase reactions, fatigue and creep behaviour.

Unit 2 **12**

Ferrous alloys: Iron-carbon equilibrium diagrams, steels and cast irons: properties, structure, composition and applications, transformation hardening in steels, TTT diagrams, heat treatment processes, effect of alloying elements, high alloy steels, stainless steel types, tool steels, manganese steels, heat resistant steels, HSLA, maraging steels.

Non-ferrous alloys: Alloys of copper, aluminium, nickel, magnesium, titanium, lead, tin and zinc: composition, heat treatment, structure, properties and applications.

Unit 3 **9**

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, refractories, abrasives, glasses, glass ceramics, advanced ceramics processing methods.

Unit 4 **9**

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 fibre-reinforced plastics, metal matrix composites and ceramic matrix composites, applications.

Unit 5 **8**

Processing: Processing of polymers, composites and ceramics; thermal spraying; ion beam machining; diamond coating techniques; tribological applications.

Prescribed Text Books:

1. **Advanced Materials and Processes** - James W. Evans and Lutgard C. De Jonghe, Springer, 2016.
2. **Engineering Metallurgy** - Raymond A. Higgins, ELBS/EA.
3. **Introduction to Material Science and Engineering, 7th Edition** - James F. Shackelford, Macmillan, New York.

Reference Books:

1. **Powder Metallurgy, ASM Metals Handbook** - ASM, USA, Vol. 7, 1974.
2. **Composite Materials: Science and Engineering, 2nd Edition** - K.K. Chawla, Springer-Verlag, New York, 1998.
3. **Cast Metal Matrix Composites, ASM Metals Handbook, Vol. 15** - P.K. Rohatgi.
4. **Elements of Material Science and Engineering** - L.H. Van Vlack, Addison-Wesley, New York, 1989.
5. **Materials Science and Engineering: An Introduction** - W.D. Callister, John Wiley & Sons.

Title of the Course	**:**	SURFACE TREATMENT AND FINISHING
Course Code	**:**	26CMEC0KT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the fundamentals of electroplating and hot dip metal coating processes.
2. Describe vacuum coating, CVD/PVD, metal spraying and plasma coating.
3. Explain plastic coating, phosphating, sherardizing and the testing of surface coatings.
4. Describe heat treatment methods for engineering components.
5. Introduce advanced coating technologies and coating characterization.

Course Outcomes:

1. Select and apply electroplating and hot dip coating processes for given applications.
2. Select vacuum deposition and spraying processes with proper surface preparation.
3. Evaluate plastic and phosphate coatings and test the quality of surface coatings.
4. Specify heat treatment cycles for gears, spindles and cutting tools.
5. Evaluate hard facing, electrodeposition and nano-coatings and characterize coated surfaces.

Unit 1 **10**

Fundamentals of electroplating: Galvanizing, hot dip metal coating, thin coatings, chromium plating, nickel plating.

Unit 2 **10**

Vacuum coating and metal spraying: Vacuum coating, PVD and CVD, metal spraying: methods, surface preparation, mechanical properties of sprayed metals, plasma coating.

Unit 3 **10**

Plastic and conversion coatings: Plastic coating of metal: PVC coating, sherardizing process details, phosphate coating: mechanism of formation. Testing of surface coatings: methods.

Unit 4 **9**

Heat treatment methods: Annealing, normalizing, tempering, case hardening methods, flame hardening, sub-zero treatment. Heat treatment methods for gears, spindles and cutting tools.

Unit 5 **9**

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

Prescribed Text Books:

1. **Surface Preparation and Finishes for Metals** - James A. Murphy, McGraw-Hill.

2. **Principles of Metal Surface Treatment and Protection, 2nd Edition** - David R. Gabe, Pergamon Press, Oxford / New York, 1978.

Reference Books:

1. **Mahendra (Mark) Schlesinger and Milan Paunovic (eds.)**, *Modern Electroplating*, 5th ed., Wiley, 2010
2. **Donald M. Mattox**, *Handbook of Physical Vapor Deposition (PVD) Processing*, 2nd ed., Elsevier / William
Andrew, 2010
3. **Hugh O. Pierson**, *Handbook of Chemical Vapor Deposition (CVD): Principles, Technology and Applications*, 2nd ed., Noyes / William Andrew, 1999
4. **Joseph R. Davis (ed.)**, *Handbook of Thermal Spray Technology*, ASM International, 2004
5. **Vijay K. Sharma / Sidney H. Avner**, *Introduction to Physical Metallurgy*, 2nd ed., McGraw-Hill, 1974

Title of the Course	**:**	BIO MATERIAL AND TECHNOLOGY
Course Code	**:**	26CMEC0LT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce the classification and properties of biomaterials and the use of metallic implant materials.
2. Describe polymeric and ceramic implant materials and host tissue reactions.
3. Explain composite implant materials, biocompatibility and toxicological screening.
4. Describe in vitro, in vivo and ex vivo testing of biomaterial implants.
5. Explain sterilisation techniques and their effects on material properties.

Course Outcomes:

1. Classify biomaterials and relate their properties to physiological environments.
2. Select suitable metallic, polymeric and ceramic implant materials for specific applications.
3. Evaluate composite implants and assess biocompatibility using standard toxicity tests.
4. Plan mechanical and biological testing of implant materials according to standards.
5. Select an appropriate sterilisation technique and assess its effect on material properties.

Unit 1 **11**

Introduction: Definition of biomaterial, classification of biomaterials, comparison of properties of some common biomaterials, effects of physiological fluid on properties of biomaterials, surface properties, physical and mechanical properties of biomaterials.

Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys, importance of stress corrosion cracking, host tissue reaction with biometals, corrosion behaviour, hard tissue replacement implants, orthopaedic implants, dental implants, percutaneous and skin implants, vascular implants, heart valve implants.

Unit 2 **12**

Polymeric implant materials: Polyolefins, polyamides, acrylic polymers, fluorocarbon polymers, silicone rubber, acetals. Viscoelastic behaviour, creep recovery, stress relaxation, strain rate sensitivity, importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives, ageing and environmental stress cracking, physicochemical characteristics of biopolymers, biodegradable polymers for medical purposes and their biological applications.

Ceramic implant materials: Definitions of bioceramics, common types of bioceramics, aluminium oxides, glass ceramics, carbons. Bioresorbable and bioactive ceramics, importance of wear resistance and low fracture toughness. Host tissue reactions, importance of interfacial tissue reaction.

Unit 3 **11**

Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fibre reinforcement, polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.

Biocompatibility and toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility 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 **8**

Testing of biomaterial implants: In vitro testing (mechanical testing): tensile, compression, wear, fatigue, corrosion studies and fracture toughness. In vivo testing (animals): biological performance of implants. Ex vivo testing, standards of implant materials.

Unit 5 **6**

Sterilisation techniques: ETO, gamma radiation, autoclaving, effects of sterilisation on material properties.

Prescribed Text Books:

1. **Biological Performance of Materials** - Jonathan Black, Marcel Dekker, 1981.
2. **Blood Compatible Materials and Devices** - C.P. Sharma and M. Szycher, Technomic Publishing Co. Ltd., 1991.

Reference Books:

1. **Polymeric Biomaterials** - E. Piskin and A.S. Hoffman, Martinus Nijhoff Publishers, Dordrecht, 1986.
2. **Biomaterials: Science and Engineering** - J.B. Park, Plenum Press, 1984.
3. **Biomaterials** - Sujata V. Bhat, Narosa Publishing House, 2002.

Title of the Course	:	SIMULATION MODELLING AND ANALYSIS OF MANUFACTURING SYSTEMS
Course Code	:	26CMEC0MT
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Introduce manufacturing systems, performance measures and the role of analytical and simulation models.
2. Explain the principles of discrete event simulation, model verification and validation.
3. Describe Markov chain models for manufacturing systems.
4. Explain queuing models, queuing networks and Petri net models of manufacturing systems.
5. Introduce simulation software and languages for the simulation of manufacturing systems.

Course Outcomes:

1. Describe manufacturing systems and select suitable modelling approaches for performance analysis.
2. Develop and validate discrete event simulation models using random number generators.
3. Analyze manufacturing systems using discrete and continuous time Markov chain models.
4. Evaluate system performance using M/M/1, M/M/m queues, queuing networks and GSPN models.
5. Simulate manufacturing systems using simulation languages and compare simulation tools.

Unit 1 **10**

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 of automated manufacturing systems, role of performance modelling, nature of models, basic approach to modelling, types of models, analytical versus simulation models: need for both.

Unit 2 **10**

Simulation modeling: The nature of simulation, system 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 **9**

Markov chain models: Review of basic probability and statistics, estimation of means and variances, memoryless random variables, geometric and exponential random variables, stochastic processes in manufacturing, discrete time Markov chain models, continuous time Markov chain models, semi-Markov processes in manufacturing.

Unit 4 **10**

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.

Petri net models: Classical Petri nets, stochastic Petri nets, generalized stochastic Petri nets (GSPN), GSPN modelling of typical manufacturing systems.

Unit 5 **9**

Simulation of manufacturing systems: Objectives of simulation in manufacturing, simulation software for manufacturing applications, modelling system randomness, sources of randomness, machine downtimes, examples. Simulation languages: comparison of simulation languages with general-purpose languages, simulation languages versus simulators, software features, statistical capabilities, GPSS, SIMAN, SIMSCRIPT, simulation of M/M/1 queue, comparison of simulation languages.

Prescribed Text Books:

1 . Ronald G. Askin and Charles R. Standridge, *Modeling and Analysis of Manufacturing Systems*, Wiley, 1993

2. **Geoffrey Gordon**, *System Simulation*, 2nd ed., Prentice-Hall of India, 1978 (Eastern Economy Edition)

Reference Books:

1. **Performance Modeling of Automated Manufacturing Systems** - N. Viswanadham and Y. Narahari, PHI, 1994.
2. **Stochastic Models of Manufacturing Systems** - John A. Buzacott and J. George Shanthikumar, Prentice Hall, Englewood Cliffs, USA, 1993.
3. **Simulation Modeling and Analysis** - 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	:	26CMEC0NT
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Introduce computer integrated manufacturing systems and the architecture of NC/CNC machine tools.
2. Explain interpolation, control loops and the constructional features of CNC machines.
3. Explain NC part programming, DNC and adaptive control systems.
4. Introduce industrial robotics technology, control, programming and applications.
5. Explain computerized manufacturing planning and control systems.

Course Outcomes:

1. Describe the elements and benefits of CIMS and the components of a CNC system.
2. Explain interpolation methods and design considerations for accurate CNC machines.
3. Develop manual and CAM-based part programs for turning and milling and explain DNC and adaptive control.
4. Select robot configurations, drives, sensors and programming methods for industrial applications.
5. Apply computer aided process planning, production planning and shop floor control concepts.

Unit 1 **10**

Introduction to computer integrated manufacturing systems: Manufacturing systems, types of manufacturing systems, machine tools and related equipment, 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 system: machine control unit, CNC driving system components: hydraulic, servo motors, stepper motors; feedback devices: encoder, resolver, Inductosyn, tachometers, counting devices, digital to analog converters.

Unit 2 **10**

Interpolations: DDA integrators, simple and symmetrical DDA, reference word CNC interpolators.

Control loops for NC 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, slideways, bearings, recirculating ball screws, spindle drives, work holding devices and tool holding devices, automatic tool changers: principles of operation, machining centres, tooling for CNC machines.

Unit 3 **10**

NC part programming: Introduction, NC/CNC programming methods: manual part programming for turning and milling centres, 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 and 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 **9**

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 **9**

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** - M.P. Groover, Prentice Hall India (P) Ltd., 1989.
2. **CAD/CAM: Computer Aided Design and Manufacturing** - Mikell P. Groover and Emory W. Zimmers Jr., Prentice Hall India (P) Ltd., 1992 (Unit 1).

Reference Books:

1. **Numerical Control of Machine Tools** - J. Martin.
2. **CAD/CAM Principles and Applications** - P.N. Rao, McGraw-Hill, 2002.
3. **Numerical Control of Machine Tools** - Y. Koren and J. Ben-Uri, Khanna Publishers, 1992.
4. **Numerical Control in Manufacturing** - F.W. Wilson, McGraw-Hill, New York.
5. **Theory and Design of CNC Systems** - Suk-Hwan Suh, Seong-Kyoon Kang, Dae-Hyuk Chung and Ian Stroud, Springer, 2008.

ANNAMACHARYA UNIVERSITY

(ESTD UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT,
(UNIVERSITY LISTED IN UGC AS PER THE SECTION 2(f) OF THE UGC ACT, 1956)

RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	ADVANCED MANUFACTURING TECHNIQUES
Course Code	**:**	26CMEC0OT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Explain the development, classification and selection of non-conventional manufacturing processes.
2. Describe the mechanics of material removal in ultrasonic, abrasive and water jet, electrochemical, chemical and electrical discharge machining.
3. Explain electron beam and ion beam machining and high energy rate forming methods.
4. Describe laser beam, electron beam, water jet and abrasive jet machining and related grinding and discharge processes.
5. Introduce hybrid machining systems, the economics of advanced machining and high velocity forming of metals.

Course Outcomes:

1. Select a suitable non-conventional process for a given material, geometry and accuracy requirement.
2. Analyze the effect of process parameters on MRR, accuracy and surface finish in USM, AJM, ECM and EDM.
3. Explain the working and applications of EBM, IBM and HERF processes.
4. Compare laser, electron beam, water jet and abrasive jet machining for engineering applications.
5. Evaluate hybrid machining and high velocity forming processes on technical and economic grounds.

Unit 1 **10**

Introduction: Development and classification of non-conventional manufacturing processes, considerations in process 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 **10**

Mechanical, electrochemical and chemical processes: Ultrasonic machining (USM), abrasive jet and water jet machining (AJM), electrochemical machining (ECM), electrochemical grinding (ECG), chemical machining (CHM), electrical discharge machining (EDM).

Unit 3 **9**

Beam processes and HERF: Electron beam machining (EBM) and ion beam machining (IBM) processes. High energy rate forming (HERF) methods.

Unit 4 **9**

Advanced machining processes: Electrochemical grinding, electrical discharge machining, laser beam machining, electron beam machining, water jet machining, abrasive jet machining.

Unit 5 **10**

Hybrid and high velocity processes: Hybrid machining systems, economics of advanced machining processes. High velocity forming of metals: explosive forming, electro-hydraulic forming, magnetic pulse forming, applications of HERF techniques.

Prescribed Textbooks:

1. V.K. Jain, *Advanced Machining Processes*, Allied Publishers, 2002
2. Hassan El-Hofy, *Advanced Machining Processes: Nontraditional and Hybrid Machining Processes*, McGraw-Hill, 2005

Reference Books:

1. **Modern Machining Processes** - P.C. Pandey and H.S. Shan, Tata McGraw-Hill, New Delhi.
2. **Non Conventional Machining** - P.K. Mishra, Narosa Publishing House, New Delhi.
3. **New Technology** - Amitabha Bhattacharyya, Institution of Engineers (India), Calcutta.
4. **High Velocity Forming of Metals** - ASTME, PHI, New Delhi.
5. **Manufacturing Science** - A. Ghosh and A.K. Mallik, New Age Publishers Pvt. Ltd., New Delhi.
6. **Manufacturing Engineering and Technology** - Serope Kalpakjian and Steven R. Schmid, Addison Wesley, New Delhi.

ANNAMACHARYA UNIVERSITY

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RAJAMPET, YSR District, AP – 516126, INDIA

Title of the Course	**:**	AGILE MANUFACTURING
Course Code	**:**	26CMEC0PT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce the concept of agile manufacturing and the competitive environment that drives it.
2. Explain the four core concepts of agile manufacturing.
3. Describe the change management implications of moving from traditional to agile manufacturing.
4. Explain the design of the agile manufacturing enterprise using interdisciplinary design.
5. Introduce skill and knowledge enhancing technologies for agile manufacturing.

Course Outcomes:

1. Explain the business case and conceptual framework for agile manufacturing.
2. Apply the core concepts of strategy-driven, integrated and interdisciplinary design to manufacturing organizations.
3. Analyze the organizational, accounting and technological changes required for agility.
4. Develop a model for the design of an agile manufacturing enterprise.
5. Evaluate skill and knowledge enhancing technologies for machine tool systems.

Unit 1 **8**

Introduction: Agile manufacturing, competitive environment of the future, the business case for agile manufacturing, conceptual framework for agile manufacturing.

Unit 2 **8**

Four core concepts: Strategy-driven approach, integrating organization, people and technology, interdisciplinary design methodology.

Unit 3 **12**

Agile manufacturing and change management: The change implications. Past 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 the workplace, organizational issues, role of technology.

Unit 4 **10**

Agile manufacturing enterprise design: Enterprise design, system concepts as the basic manufacturing theory, joint technical and organizational design and a model for the design of an agile manufacturing enterprise, enterprise design process, insights into design processes, what is interdisciplinary design, main issues, simple design example.

Unit 5 **10**

Skill and knowledge enhancing technologies for agile manufacturing: Skill and knowledge enhancing technologies: scheduling, technology design, strategic design concepts. Design of skill and knowledge enhancing technologies for machine tool systems: historical overview, lessons, problems and future development.

Prescribed Textbooks:

1. Steven L. Goldman, Roger N. Nagel and Kenneth Preiss, Agile Competitors and Virtual Organizations: Strategies for Enriching the Customer, Van Nostrand Reinhold, 1995
2. A. Gunasekaran (ed.), Agile Manufacturing: The 21st Century Competitive Strategy, Elsevier, 2001

Reference Books:

1. **Agile Manufacturing: Forging New Frontiers** - Paul T. Kidd, Addison-Wesley, 1994.
2. **Agile Manufacturing** - M.P. Chowdiah (Ed.), Tata McGraw-Hill, 1996.
3. **On Agile Manufacturing** - M.P. Chowdaiah, Tata McGraw-Hill, 1996.
4. **Agile Manufacturing Systems** - K. Hans Raj, Alpha Science International Limited.

Title of the Course	:	ADVANCED MATERIAL SCIENCE AND ENGINEERING PROCESS
Course Code	:	26CMEC0QT
Course offered to	:	ME
Credits	:	4

Course Objectives

1. Classify engineering materials and explain atomic structure, defects and strengthening mechanisms.
2. Describe ferrous and non-ferrous alloys, their structure, properties and heat treatment.
3. Explain casting processes, with emphasis on stir casting of metal matrix composites.
4. Introduce the Taguchi method and analysis of variance for process optimization.
5. Describe electron microscopy and X-ray based techniques for materials characterization.

Course Outcomes:

1. Relate structure, defects and strengthening mechanisms to the properties of metals.
2. Select ferrous and non-ferrous alloys and heat treatment processes for given applications.
3. Analyze the factors affecting the stir casting process and the quality of cast composites.
4. Apply Taguchi orthogonal arrays and ANOVA to optimize material processing parameters.
5. Interpret SEM, TEM, SAED, AFM and XRD results for material characterization.

Unit 1 **9**

Classification and characteristics: Metals: ferrous and non-ferrous metals and their classification; composites and classification of composites.

General properties and structure: Atoms, molecules, bonds in solids, crystalline structure, defects in metallic structure, dislocations and plastic deformation, strengthening mechanism: grain size.

Unit 2 **10**

Non-ferrous alloys: Alloys of copper, aluminium, nickel, magnesium, titanium, lead, tin and 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, TTT diagrams, heat treatment processes.

Unit 3 **11**

Casting and transformation processes: Classification, characteristics of sand casting processes, metal mould casting processes. Advanced casting: principle of stir casting, steps in the stir casting process, factors affecting the 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 **9**

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 **9**

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.

Prescribed Textbooks:

1. **Engineering Metallurgy** - Raymond A. Higgins, ELBS/EA.
2. **Introduction to Material Science and Engineering, 7th Edition** - James F. Shackelford, Macmillan, New York.
3. **Advanced Materials and Processes** - James W. Evans and Lutgard C. De Jonghe, Springer, 2016.

Reference Books:

1. **Design of Experiments with MINITAB** - Paul Mathews, New Age International.
2. **Elements of Material Science and Engineering** - L.H. Van Vlack, Addison-Wesley, New York, 1989.
3. **Materials Science and Engineering: An Introduction** - W.D. Callister, John Wiley & Sons.

Title of the Course	**:**	TECHNOLOGY OF SURFACE COATINGS
Course Code	**:**	26CMEC0RT
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Introduce the nature, ingredients, classification and application of paints.
2. Explain drying oils, driers, the drying process and water-borne paints.
3. Describe the process of pigmentation and the methods of pigment dispersion.
4. Explain the testing and evaluation of raw materials, liquid paints and dry films.
5. Describe surface preparation, paint application techniques and the prevention of paint defects.

Course Outcomes:

1. Classify paints and describe their ingredients, film formation and pigment volume concentration.
2. Select suitable drying oils, driers and water-borne binders for a given coating.
3. Select pigment dispersion methods and equipment for aqueous and non-aqueous paints.
4. Test pigments, resins, liquid paints and dry films using standard methods.
5. Plan surface preparation and application methods and diagnose common paint defects.

Unit 1 **9**

Basic concepts: The nature of paint, ingredients of paints, classification of paints: high build, high solids and solvent paints, application of paints, paint film, coverage rate and pigment volume concentration.

Unit 2 **10**

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 emulsion paints, materials and manufacturing of vinyl emulsion paints, acrylic emulsions and paints, water-soluble binders.

Unit 3 **10**

Process of pigmentation, methods of pigment dispersion: Non-aqueous paints: breakdown of aggregates, wetting of pigment particles, 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 **10**

Testing and evaluation: Testing of pigments, extenders, oils, resins and solvents; testing of liquid paints: application and wet films, sag resistance, drying time, measurement of drying time,

overcoating time. Tests on dry films: mechanical properties, optical properties, chemical resistance and corrosion resistance.

Unit 5 **9**

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

Prescribed Textbook:

1. **Zeno W. Wicks Jr., Frank N. Jones, S. Peter Pappas and Douglas A. Wicks**, *Organic Coatings: Science and Technology*, 3rd ed., Wiley, 2007

Reference Books:

1. **Organic Coating Technology, Vol. I and II** - H.F. Payne.
2. **Outlines of Paint Technology** - W.M. Morgans.
3. **Surface Coatings, Vol. I and II** - OCCA, Australia.
4. **Basics of Paint Technology (Part I and II)** - Malshe and Sikchi.
5. **Indian Standards** - IS 33:1992, IS 3493:1978, IS 74:1979, IS 101:1964, IS 2932, IS 2074.

Title of the Course	**:**	ADVANCED INTERNAL COMBUSTION ENGINES
Course Code	**:**	26CMEC0ST
Course offered to	**:**	ME
Credits	**:**	4

Course Objectives

1. Summarize the fundamental principles, classification, working cycles, and performance characteristics of two-stroke and four-stroke SI and CI engines.
2. Comprehend the combustion processes in SI and CI engines, including ignition, flame propagation, knocking, and combustion chamber design considerations.
3. Familiarize students with fuel injection systems, fuel pumps, injectors, nozzles, and fuel spray characteristics used in CI engines.
4. Explain the working principles and design features of engine cooling and lubrication systems and their importance in engine operation.
5. Provide knowledge of conventional and alternative fuels, fuel cells, engine emissions, and emission control technologies

Course Outcomes:

1. Classify IC engines and explain their working principles, valve and port timing diagrams, and performance parameters.
2. Analyze the combustion processes in SI and CI engines and explain the causes and effects of abnormal combustion and knocking.
3. Evaluate the working and performance of fuel injection systems, injectors, and spray formation mechanisms in CI engines.
4. Compare different engine cooling and lubrication systems based on their construction, working principles, and operating requirements.
5. Assess the suitability of conventional and alternative fuels and evaluate engine emission control techniques for reducing environmental pollution

Unit 1 12

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 11

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 14

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 **13**

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 12

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.

Prescribed Textbook:

1. Internal Combustion Engines by V.Ganeshan, 4th Edition, McGraw Hill Education (India), 2012. ISBN: 978-1-25-900619-7.

2. Internal Combustion Engine fundamentals by **J. B. Heywood,** McGraw Hill, ISBN-0- 188 07-100499-8

Reference Books:

1. A Course in Internal Combustion Engines **by M.L. Mathur and R.P. Sharma,** Dhanpat Rai and Sons, 2016, ISBN: 978-93-83182-42-8

2. Computer Simulation of Spark-Ignition Engine Processes **by V. Ganeshan,** Universities Press, 1996. ISBN: 978-81-7371-015-5. 96.