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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| **Group-1** | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| 1 | 16MDE11 | Applied Mathematics |
| 2 | 16MCM12 | Automation & Comp. Integrated Manufacturing |
| 3 | 16MCM13 | Computer Aided Design |
| 4 | 16MCM151 | Finite Element Method |
| 5 | 16MCM152 | Artificial Intelligence & Expert Systems |
| 6 | 16MDE152 | Computer Applications in Design |
| 7 | 16MDE153 | Mechatronics System Design |
| 8 | 16MAR21a | Robotics for Industrial Automation |
| 9 | 16MST424 | Experimental Methods in Engineering |
| 10 | 16MCS24 | Modeling & Simulation |
| 11 | 16MTR153 | Industrial Automation |
| 12 | 16MTR22 | Advanced Embedded System |
| 13 | 16MTR41 | Programmable Logic Controller |
| 14 | 16MTR12 | Fluid Power Automation |

| **Group-2** | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| 1 | 16MCS11 | Advanced Mathematics |
| 2 | 16MDE12 | Finite Element Method |
| 3 | 16CAE13 | Continuum Mechanics |
| 4 | 16CAE14 | Experimental Mechanics |
| 5 | 16MDE151 | Computer Graphics |
| 6 | 16MST22 | Smart Materials & Structures |
| 7 | 16MAR156 | Modern Control Engineering |
| 8 | 16CAE421 | Fracture Mechanics |
| 9 | 16MDE22 | Advanced Machine Design |
| 10 | 16MCM422 | Dynamics & Mechanism Design |
| 11 | 16MMD41 | Tribology and Bearing Design |
| 12 | 16MDE24 | Advanced Theory of Vibrations |
| 13 | 16MDE254 | Rotor Dynamics |
| 14 | 16MTR254 | Experimental Techniques |

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| Group-3 | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| 1 | 16MTP13 | Advanced Fluid Mechanics |
| 2 | 16MTP14 | Thermodynamics & Combustion Engineering |
| 3 | 16MTP151 | Nonconventional Energy System |
| 4 | 16MTP154 | Refrigeration and Air Conditioning |
| 5 | 16MTP41 | Design of heat Transfer Equipment for Thermal Power production |
| 6 | 16MCS154 | Solar Energy Engineering |
| 7 | 16MTP252 | Alternate Fuels for IC Engines |
| 8 | 16MTP421 | Convective Heat and Mass Transfer |
| 9 | 16MTP422 | Engine Flow & Combustion |
| 10 | 16MTP423 | Design & Analysis of Thermal Systems |
| 11 | 16MTP424 | Experimental Methods in Thermal Power Engineering |
| 12 | 16MTP21 | Advanced Heat Transfer |
| 13 | 16MCS421 | Wind Energy Engineering |
| 14 | 16MTP23 | Advanced Power Plant Cycles |

| Group-4 | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| 1 | 16MST14 | Nano Science and Nano Materials |
| 2 | 16MST151 | Advances in Materials and Processing |
| 3 | 16MST152 | Advanced Foundry Technology |
| 4 | 16MST21 | Composite Materials Technology |
| 5 | 16MST41 | Plastic Processing |
| 6 | 16MST13 | Materials for Cryogenic & High Temperature |
| 7 | 16MST23 | Testing of Materials |
| 8 | 16MCS254 | Nano Technology |
| 9 | 16MCS423 | Analysis & Design of Composites |
| 10 | 16MST153 | Non Destructive Testing |
| 11 | 16MST422 | Bio Materials & Technology |
| 12 | 16MST423 | Mechanical Behavior of Materials |
| 13 | 16MST251 | Surface Treatment And Finishing |
| 14 | 16MST154 | Selection of Materials in Engineering |

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| **Group-5** | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| **1** | 16MTR423 | Vibration Analysis |
| **2** | 16MTR13 | Advanced Control Systems |
| **3** | 16MTR154 | Mechatronics System in Automobile Engineering |
| **4** | 16MTR151 | Automotive Electronics |
| **5** | 16MTR251 | Finite Element Methods |
| **6** | 16MAR424 | Concurrent Engineering for Manufacturing |
| **7** | 16MEA 424 | Computational Fluid Dynamics |
| **8** | 16MTR152 | Micro and Smart Systems Technology |
| **9** | 16MCM22 | Flexible Manufacturing Systems |
| **10** | 16MST421 | Modeling, Simulation & Analysis of |
| **11** | 16CAE251 | Design Optimization |
| **12** | 16MTR421 | Artificial Intelligence and Neural Networks |
| **13** | 16MTR21 | Advanced Electronic Drives |
| **14** | 16MTR23 | Sensor and Signal Conditioning |

| **Group-6** | | |
|---|---|---|
| **Sl. No.** | **SUBJECT CODE** | **SUBJECT TITLE** |
| 1 | 16MCM153 | Rapid Prototyping |
| 2 | 16MCM154 | Agile Manufacturing |
| 3 | 16MAR155 | Modeling of Management Information Systems |
| 4 | 16MTR253 | Product Design |
| 5 | 16MCS253 | Projects Analysis and Management |
| 6 | 16MDE154 | Design for Manufacture |
| 7 | 16MTR422 | Reliability and Failure Analysis |
| 8 | 16MTP152 | Nuclear Energy Conservation |
| 9 | 16MCM252 | Concurrent Engineering & Product Life Cycle |
| 10 | 16MAR23a | Computer Control of Manufacturing Systems |
| 11 | 16MCS13 | Optimization Techniques |
| 12 | 16MAR423 | Tooling for Manufacture in Automation |
| 13 | 16MAR14a | Automation in Manufacturing Systems |
| 14 | 16MAR421 | Production Planning and Control |

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| 01 | 16MDE11 | Group-1 | APPLIED MATHEMATICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Modules**

**Module 1.** Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors.
Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering.

**Module 2 .**Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed point iteration.
Roots of polynomial-Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.

**Module 3.** Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formu Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accu differentiation formulae.

**Module 4.** System of Linear Algebraic Equations And Eigen Value Problems: Introduction, Direct methods, Cramer' Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method Partition method, error Analysis for direct methods, Iteration Methods.
Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder's method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.

**Module 5.** Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Line Models in Science and Engineering.
Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-Schmidt process, Least Square problems, Inner product spaces**.**

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003


**Reference Books:**


1. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.
2. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.

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| 02 | 16MCM12 | Group-1 | AUTOMATION AND COMPUTER INTEGRATED MANUFACTURING |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**MODULE 1**

**Production Development Through CIM:** Computers in Industrial manufacturing, Product cycle & Production development cycle, Introduction of CAD/CAM & CIM, sequential and concurrent engineering, soft and hard prototyping.

**MODULE 2**

**Computer Integrated Manufacturing and Automation:** Fundamentals of CAD/CAM, Computerized Manufacturing planning systems, shop floor control & automatic identification techniques. Computer Network for manufacturing and the future automated factor.

**Detroit Type of Automation:** Flow lines, Different Transfer Mechanisms, work pattern transfer, Different methods.

**MODULE 3**

**Analysis of Automated flow lines:** Analysis of transfer lines without storage, with storage buffer, single stage, Double stage, Multistage with problems, Automated assembly systems, Design for automated assembly, parts feeding devices..

**Computer Process Monitoring:** Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control.

**MODULE 4**

**Automated Material Handling and Storage:** Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.

**MODULE 5**

**Robotics in Material Handling**

General considerations in robot material handling – material transfer application – pick &place operations – machine loading & unloading – characteristics of robot application.

**Computer Aided Quality Control:** The computer in Q.C, automated inspection principles and methods, Contact inspection methods, non-contact inspection methods, machine vision system, optical inspection method, sensors, coordinate measuring machine.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. CAD/CAM – Zimmers& Grover, PHI.
2. CAD/CAM/CIM – P. Radhakrishna, New Age Internationa l.
3. M. P. Grover, Automation, Production Systems & Computer Aided manufacturing, Prentice Hall.

**REFERENCE BOOKS:**

1. CAD/CAM – Zeid, Mc-Graw Hill
2. CAD/Cam, P. N. Rao.
3. Koren.Y “Robotics for Engineering” Mc-Graw Hill.
4. Rooks. B. (ed) “Robert vision & Sensory controls vo l-3 North Holland.

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| 03 | 16MCM13 | Group-1 | COMPUTER AIDED DESIGN |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**MODULE 1**

**Introduction to Computer graphics and Database**: Computer Aided Design: Definition, Fundamentals of CAD, The Design Process, Computers Applications in Design, Manufacturing Database, Benefits of CAD, Computer Graphics Software and Database: Software configuration of a Graphic system, Functions of a Graphics package, Constructing the Geometry, Database Structure and Content, Wire-Frame Features & CAD/CAM Integration.

**MODULE 2**

**TRANSFORMATIONS**-Translation, Scaling, Reflection or Mirror, Rotation, Concatenations, Homogeneous Transformation, 3D Transformations-Translation, Scaling, Rotation about, X, Y and Z axes. Mathematics of Projections- Orthographic and Isometric Projections. Clipping, Hidden Line or Surface removal, Color and Shading.

**GEOMETRIC MODELING:** Requirements of Geometric Modeling, Geometric Models, Geometric Construction Methods, Constraint- Based Modeling.

**MODULE 3**

**MODELING FACILITIES AND GRAPHIC STANDARDS:** Modeling Facilities-Geometric Modeling Features, Editing or Manipulating, Display Control, Drafting, Programming, Analytical and Connecting Features.

**GRAPHIC STANDARDS** - Standardization in Graphics, Graphical Kernel System (GKS), Other Graphic Standards-GKS 3D, PHIGS, NAPLPS, Exchange of Modeling Data-IGES, STEP, Drawing Exchange Format (DXF), Dimension Measurement Interface Specification (DMIS).

**MODULE 4**

**MODELING CURVES &SURFACES:** Curve Representation-Line, Circle, Parabola, Hyperbola, Curve Fitting-Interpolation Techniques- Lagrangian Polynomial, B-Splines, Approximate Methods-Method of Least Squares, Polynomial Curve Fitting, Synthetic Curves-Hermite Cubic Spline, Bermestine Polynomials.

**SURFACE REPRESENTATION:** Methods-Analytic Surfaces, Surfaces of Revolution, Ruled Surfaces, Synthetic Surfaces- Hermite Cubic Surface, Bezier Surface, Surface Patch, Tabulated Cylinder, Sculptured Surfaces.

**MODULE 5**

**VIRTUAL AND RAPID PROTOTYPING**: Introduction to Virtual modeling, Rapid prototyping, RP data formats and Information workflow, Classifications of RP, Process involving Liquid, discrete particle and solid sheet of standard methods of each, Technical characteristics of standard methods. Applications of RP.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. P.N. Rao, CAD/CAM Principles and Applications, 3rd Ed., McGrawHill, Education Pvt Ltd., New Delhi
2. Ibrahim Zeid& R.Shivasubramanian, CAD/CAM Theory & Practice, 2nd Ed., TMH Education Pvt Ltd., New Delhi (Chapter 2,)

**REFERENCE:**

1. M.P. Groover and EW Zimmers, CAD/CAM Computer aided DesignandManufacture,Prentice hall, 1984
2. C.B. Besant and E.W.K. Lui, Computer Aided design and Manufacture, Affiliated East West, press India 1988
3. Piegel ,Mathematical Elements for Computer Graphics,

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| 04 | 16MCM151 | Group-1 | FINITE ELEMENT METHOD |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Finite Element Modeling and Analysis:** Introduction, Basic Concepts, Engineering Applications, Features, steps in FEM. Discretisation of domain, discussion on various 1D, 2D and 3D Elements

**Discretisationand ShapeFunctions:**Discretisation Process, various consideration for discretisation Process. Derivation of shape function for 1D and 2D element. Comparison of 1D linear, 1D quadratic and 1D cubic element. Convergence requirements

**Finite Element Formulation of Solid Mechanics Problems:** Potential Energy Formulation and Closed form Solution, Weighted Residual Method, Galerkin Method. Problems on 1D elements.

**Analysis of Structures:** Truss Elements, Analysis of Truss Problems by Direct Stiffness Methods, Analysis of Frames and Different Problems, Different Axi-Symmetric Truss Problems.

**Computer Aided Engineering Analysis:** Introduction, Conventional Approach to Design, Description of the Design Process, Parametric and Variation Designs, Engineering Analysis and CAD, Compute Aided Engineering, Integrated Database Management System in CAE, CAE product Development, CAE implementation, Simulation Based Design.

**Transformation and Manipulation of Objects:** Introduction, Transformation Matrix, 2D transformation, Arbitrary Rotation about the origin, Rotation by different angles, Concatenation, 2D transformation, Projection on to a 2D plane, Overall scaling, Rotation about an Arbitrary Point, 2D Reflection, 3D Transformation, 3D scaling, 3D Rotation of Objects, 3D Rotation about an arbitrary Axis, 3D Visualisation.

**Geometric Modeling:**Line Fitting, Non Linear Curve Fitting with a Power Function, Curve Fitting with a High Order Polynomial,Cubic Spines, Parabolic Cubic Splines, Non Parametric Cubic Spline, Boundary Conditions, Bezier Curves, Differentiation of Bezier Curve Equations, B-Spline Curve, Non Uniform Rational B-Spline(NURBS), Surface creation, Plane Surface, Ruled Surface, Rectangular Surface, Surface of Revolution, Application Software. Introduction, Construction Techniques, Representation Schemes, and Application of Solid Modeling.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. **"Finite Element Procedure"-** Bathe, Prentice Hall, 1996..
2. **"Finite Elements in Engineering"** – Chandrupatla, and Belagundu, Prentice Hall of India Pvt. Ltd., New Delhi / Pearson Education, 2000.
3. **"CAD/CAM Theory and Practice**, Ibrahim-Zeid, TATA McGraw Hill, 2009.
4. **"Principles of Computer Aided Design and Manufacturing"**, 2nd Edition, Pearson Publishers, FaridAmirouche, 2006
5. **CAD/CAM/CI,** P. Radhakrishnan, New age international, 2000.


**Reference Books:**


1. **"The Finite Element Method"** – Zienkiewicz.O.C. , TMH, New Delhi, 2000
2. **'Concepts and Applications of Finite Element Analysis**:" - COOK. D. Robert., Malus.S.David, Plesha E. Michel , John Wilely& sons 3rd Edn., New York, 2000
3. **"Finite Element Analysis"**– C.S.Krishnamoorthy, TMH, New Delhi, 1995
4. **"Introduction to the Finite Element method"**–Desai / ABEL C.B.S. Publisher, Distributors, New Delhi 2000.
5. **"An Introduction to FEM"** - J.N Reddy, TMH, 2006.
6. **"Fundamentals of Finite Element Analysis"** -David Hutton, TMH, 2005.

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| 05 | 16MCM152 | Group-1 | ARTIFICIAL INTELLIGENCE & EXPERT SYSTEMS |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module 1. Human and Machine Intelligence;** Concepts of fifth generation computing, programming AI environment, developing artificial intelligence system, definition of Expert systems, Natural Language processing, neural networks.
**Tools for Machine Thinking:** Forward chaining, Backward chaining, use of probability and fuzzy logic.

**Module 2. Expert System Development:** Choice of Domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing.
**Advanced Programming Techniques:** Fundamentals of object oriented programming, creating structure and object, object operations, involving procedures, programming applications, object oriented expert system.

**Module 3. Advanced knowledge representation for smart systems:** semantic nets-structure and objects, ruled systems for semantic nets; certainly factors, Automated learning.
**Languages in AI:** Using PROLOG to design expert systems, converting Rules to PROLOG, Conceptual example, introduction to LISP, Function evaluation, Lists, Predicates, Rule creation.

**Module 4. Expert System Tools:** General structure of an expert system shell, examples of creation of an expert system using an expert system tool.

**Module 5. Industrial Application of AI and Expert systems:** Robotic vision systems, Image p processing techniques, application to object recognition and inspection, automatic speech recognition.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Robert Levine et al; "**A Comprehensive guide to AI and Expert Systems**"- McGraw Hill Inc, 1986.
2. Henry C. Mishkoff; "**Understanding AI", BPB Publication**"-New Delhi 1986.

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| 06 | 16MDE152 | Group-1 | COMPUTER APPLICATIONS IN DESIGN |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module1. Introduction To CAD/CAM/CAE Systems**

Overview, Definitions of CAD. CAM and CAE, Integrating the Design and Manufacturing Processes through a Common Database-A Scenario, Using CAD/CAM/CAE Systems for Product Development-A Practical Example.

Components of CAD/CAM/CAE Systems: Hardware Components, Vector-Refresh (Stroke-Refresh) Graphics Devices, Raster Graphics Devices, Hardware Configuration, Software Components, Windows-Based CAD Systems.

**Module2. Basic Concepts of Graphics Programming**:

Graphics Libraries, Coordinate Systems, Window and Viewport, Output Primitives - Line, Polygon, Marker Text, Graphics Input, Display List, Transformation Matrix, Translation, Rotation, Mapping, Other Transformation Matrices, Hidden-Line and Hidden-Surface Removal, Back-Face Removal Algorithm, Depth-Sorting, or Painters, Algorithm, Hidden-Line Removal Algorithm, z-Buffer Method, Rendering, Shading, Ray Tracing, Graphical User Interface, X Window System.

**Standards**

Standards for Communicating Between Systems: Exchange Methods of Product Definition Data, Initial Graphics Exchange Specification, Drawing Interchange Format, Standard for the Exchange of Product Data. Tutorials, Computational exercises involving Geometric Modeling of components and their assemblies.

**Module3. Geometric Modeling Systems**

Wireframe Modeling Systems, Surface Modeling Systems, Solid Modeling Systems, Modeling Functions, Data Structure, Euler Operators, Boolean Operations, Calculation of Volumetric Properties, Non manifold Modeling Systems, Assembly Modeling Capabilities, Basic Functions of Assembly Modeling, Browsing an Assembly, Features of Concurrent Design, Use of Assembly models, Simplification of Assemblies, Web-Based Modeling.

Representation and Manipulation of Curves: Types of Curve Equations, Conic Sections, Circle or Circular Arc, Ellipse or Elliptic Arc, Hyperbola, Parabola, Hermite Curves, Bezier Curve, Differentiation of a Bezier Curve Equation, Evaluation of a Bezier Curve.

**Module4.** B-Spline Curve, Evaluation of a B-Spline Curve, Composition of B-Spline Curves, Differentiation of a B-Spline Curve, Non uniform Rational B-Spline (NURBS) Curve, Evaluation of a NURBS Curve, Differentiation of a NURBS Curve, Interpolation Curves, Interpolation Using a Hermite Curve, Interpolation Using a B-Spline Curve, Intersection of Curves.

**Representation and Manipulation of Surfaces:** Types of Surface Equations, Bilinear Surface, Coon's Patch, Bicubic Patch, Bezier Surface, Evaluation of a Bezier Surface, Differentiation of a Bezier Surface, B-Spline Surface, Evaluation of a-B-Spline Surface, Differentiation of a B-Spline Surface, NURBS Surface, Interpolation Surface, Intersection of Surfaces.

**Module5. CAD and CAM Integration**

Overview of the Discrete Part Production Cycle, Process Planning, Manual Approach, Variant Approach, Generative Approach, Computer-Aided Process Planning Systems, CAM-I CAPP, MIPLAN and Multi CAPP, Met CAPP,ICEM-PART, Group Technology, Classification and Coding, Existing Coding Systems, Product Data Management (PDM) Systems.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Kunwoo Lee, “Principles of CAD/CAM/CAE systems”-Addison Wesley, 1999
2. RadhakrishnanP.,etal.,“CAD/CAM/CIM”-New Age International, 2008

**Reference Books:**

1. Ibrahim Zeid, “CAD/CAM – Theory & Practice”, McGraw Hill, 1998
2. Bedworth, Mark Henderson & Philip Wolfe, “Computer Integrated Design and Manufacturing” -McGraw hill inc., 1991.
3. Pro-Engineer, Part modeling Users Guide, 1998

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| 07 | 16MDE153 | Group-1 | MECHATRONICS SYSTEM DESIGN |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**Modules**

Introduction: Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers:

Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.

Electrical Actuation Systems: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors.

System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.

Signal Conditioning: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals , Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.
MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.

Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System

Advanced Applications in Mechatronics: Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, Userfriendly design.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. W. Bolton, “Mechatronics” - Addison Wesley Longman Publication, 1999
2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

**Reference Books:**

1. Kamm, “Understanding Electro-Mechanical Engineering an Introduction to Mechatronics”- IEEE Press, 1 edition ,1996
2. Shetty and Kolk “Mechatronics System Design”- Cengage Learning, 2010
3. Mahalik “Mechatronics”- Tata McGraw-Hill Education, 2003
4. HMT “Mechatronics”- Tata McGraw-Hill Education, 1998
5. Michel .B. Histand& David. Alciatore, “Introduction to Mechatronics & Measurement Systems”–. Mc Grew Hill, 2002
6. “Fine Mechanics and Precision Instruments”- Pergamon Press, 1971.

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| 08 | 16MAR21 | Group-1 | ROBOTICS FOR INDUSTRIAL AUTOMATION |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module 1. Introduction:** Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, Concepts and Model about Basic Control System.

**Module 2. End Effectors And Robot Controls:** Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.

**Module 3. Time and Motion:** Trajectories, Smooth One-Dimensional Trajectories, Multi Dimensional Case, Multi-Segment Trajectories, Interpolation of Orientation in 3D, Cartesian Motion, Time Varying Coordinate Frames, Rotating Coordinate Frame, Incremental Motion, Inertial Navigation Systems. Mobile Robot Vehicles, Mobility, Car-like Mobile Robots, Moving to a Point, Following a Line, Following a Path, Moving to a Pose. SLE: Flying Robots.

**Module 4. Robot Arm Kinematics:** Describing a Robot Arm, Forward Kinematics, A 2-Link Robot, A 6-Axis Robot, Inverse Kinematics, Closed-Form Solution, Numerical Solution, Under Actuated Manipulator, Redundant Manipulator, Trajectories, Joint-Space Motion, Cartesian Motion, Motion through a Singularity.

**Module 5. Robot Sensing & Vision:** Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, Machine Vision System, Description, Sensing. Programming – powered, manual. Textual Robo languages – first generation, second, future generation – VAL, VAL II, simple programming – exercises.

**Question paper pattern:**

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- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. S.R. Deb, **Robotics Technology and flexible automation**, Tata McGraw-Hill Education., 2009
2.Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta,
3. **Industrial Robotics, Technology programming and Applications**, McGraw Hill, 2012.

**Reference Books**

**1. A Robot Engineering Textbook** – Mohsen Shahinpoor – Harper & Row publishers, New York, 1987.
**2. Robotics, control vision and intelligence,** Fu, Lee and Gonzalez. McGraw Hill International, 1987.
**3. Introduction to Robotics:Mechanics and Control,** John J. Craig, Pearson, 3e, 2009

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| 09 | 16MST424 | Group-1 | EXPERIMENTAL METHODS IN ENGINEERING |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module 1. Introduction:** Basic concepts of measurement methods, single and multipoint 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.

**Module 2. Design and Construction of Experimental facilities:** wind tunnel, general test rigs, Test cells for flow visualization and temperature mapping**.**

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

**Module 3. Temperature Measurement:** Measurement Design, Construction and Analysis of liquid and gas thermometers, resistance thermometer with wheat stone bridge, Thermo-electric effect, Construction, testing and calibration of thermocouples and thermopiles, Analysis of effect of bead size and shielding on time constant and frequency response, characteristics of thermocouple, pyrometers, radiation thermometers.

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

**Module 4. Flow and Velocity Measurement:** Industrial flow measuring devices, design, selection and calibration, velocity measurements, pitot tubes, yaw tubes, pitot static tubes; frequency response and time constant calculation. Hot-wire anemometer; 2d/3d flow measurement and turbulence measurement, Laser application in flow measurement, Flow visualization techniques, Combustion photography.

**Module 5. Measurement of Pressure, Force, and Torque:** Analysis of liquid manometer, dynamics of variable area and inclined manometer, Pressure transducers, Speed and torque measurement:, speed and torque measurement of rotating system.

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

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**1.** Experimental Methods for Engineers - J.P. Holman, McGraw-Hill Publications

**REFERENCE BOOKS:**

**1.** Mechanical Measurements - Beckwith M.G., Marangoni R.D. and Lienhard J.H., Pearson Education.
**2.** Measurements systems-Application and Design - E.O. Doebelin, Tata McGraw-Hill Publications.

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| 10 | 16MCS24 | Group-1 | MODELLING & SIMULATION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction and Overview:** Concept of System, System environment, element of system, system modeling, types of models, Monte Carlo method, system simulation, simulation-management laboratory, advantages limitations of system, simulation, continuous and discrete systems.
**Simulation of Continuous Systems**: Characteristics of a continuous system, comparison of numerical integration with continuous simulation system, Simulation of an integration formula.

**Module 2**. **Simulation of Discrete System:** Time flow mechanism, discrete and continuous probability
**Density Function, Generation of Random Numbers:** Testing of random numbers for randomness and for auto correlation, generation of random variates for continuous probability distributions-binomial, normal, exponential and beta distributions, combination of discrete event and continuous models.

**Module 3**. **Simulation of Queuing Systems**: Concept of queuing theory, characteristics of queues, stationary and time dependent queues, queue discipline, time series analysis, measure of system performance, Kendall 's notation, auto covariance and auto correlation function and effects in queuing systems, simulation of single server queues, multi server queues, queues involving complex arrivals and service times with blanking reneging.

**Module 4. Simulation of Inventory systems**: Rudiments of inventory theory, MRP, in process inventory, Necessity of simulation in inventory problems, forecasting and regression analysis, forecasting through simulation, generation of Poisson and Erlang variates, simulation of complex inventory situations.

**Module 5. Design of Simulation Experiments**: Length of run, elimination of initial bias. Variance reduction techniques, stratified sampling, antipathetic sampling, common random numbers, time series analysis, spectral analysis, model validation, optimization procedures, search methods, single variable deterministic case search, single variable non-deterministic case search, regenerative techniques.
**Simulation of PERT:** Simulation of-maintenance and replacement problems, capacity planning production system, reliability problems, computer time sharing problem, the elevator system.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. Loffick:**"Simulation And Modeling"-** Tata McGraw Hill
2. Dr.D.S.Hira S.Chand &Co:**"System Simulation"**

**REFERENCE BOOKS:**

1. Meelamkavil: **"Computer Simulation and Modeling"-** John Willey.
2. Gordon**:"System Simulation"-** Prentice Hall of India.
3. Averill Law & David M. Kelton: **"Simulation, Modeling and Analysis"-** TMH 3 rd Edition.

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| 11 | 16MTR153 | Group-1 | INDUSTRIAL AUTOMATION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Automation in Production & Manufacturing Systems** : Automation in Production system, Principles &Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Components of Manufacturing Systems, Classification of Manufacturing Systems, Manufacturing Cells, GT, Cellular Manufacturing, FMS, Flow lines & Transfer Mechanisms.

**Automated Assembly & Material handling Systems**: Types, Parts Feeding Devices, Storage Systems, AGV's, Overview of Material Handling Systems, Automated Material Handling Systems, Principles & Design Considerations, Material Transport Systems, and Overview of Automatic Identification Methods.

**Quality& Shop Floor Control Systems**: Traditional & Modern Quality Control Methods, SPC Tools, Inspection Principle & Practices, Inspection Technologies, Computer Aided Quality Control Steering, Contact & Non-Contact Inspection Methods, Co-Ordinate Measuring Machine, Factory Data Collection Systems, And Automatic Identification Systems.

**Control Technologies in Automation**: Industrial Control Systems, Process Industries Verses Discrete Manufacturing Industries, Continuous Verses Discrete Control, Computer Process & its forms. Sensors, Actuators & other Control System Components.

**Computer Based Industrial Control**: Introduction & Automatic Process Control, Computer Aided Process, Planning; Retrieval types, Generative type, Material Requirement Planning, Fundamental Concepts of MRP, Capacity Planning.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

1. Automation, Production Systems and Computer Integrated Manufacturing, M. P. Groover, Pearson Education
2. Computer Based Industrial Control, Krishna Kant, EEE-PHI
3. Automation, Production Systems and Computer Integrated Manufacturing, Mikell. O. Groover - PHI, New Delhi, 2002

**References**

1. An Introduction to Automated Process Planning Systems, Tiess Chiu Chang & Richard A. Wysk
2. Anatomy of Automation, Amber G.H & P.S. Amber, Prentice Hall
3. Principles of CIM by Vajpayee, PHI
4. Performance Modelling of Automated Manufacturing Systems, Viswanandham, PHI
5. CAD/CAM by Zeid, Tata McGraw Hill. 2000

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| 12 | 16MTR22 | Group-1 | ADVANCED EMBEDDED SYSTEMS |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module 1. Introduction to Embedded Systems:** Embedded systems Vs. General Computing Systems, Classifications, Major applications.
**Typical Embedded System:** Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components.

**Module 2. Hardware Software Co-Design and Programming Model:** Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs.

**Module 3. Embedded Firmware Design and Development:** Embedded Firmware Design Approaches, Embedded Firmware Development Languages **(Ch.9.1,9.2)**
**The Embedded System Development Environment**: The Integrated Development Environment (IDE), Types of Files Generated on Cross compilation, Disassembler/ELD Compiler, Simulators, Emulators and Debugging, Target Hardware Debugging, Boundary Scan.

**Module 4.Real-Time Operating System (RTOS) based Embedded System Design**: Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS **(Programming is limited to illustrative Codes only)**

**Module 5.Introduction to ARM: Advantages** and applications of ARM CORTEX M processors**,**
Software Development Flow, Compilation Flow. General Information about Cortex M3 &
M4 Processors, Programmers Model, APSR

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Book:**

1. Embedded Systems Architecture ,Programming and Desigin : Raj Kamal second
Edition Tata McGraw Hill Publication 2010

**Reference Books:**

1. MSP430 Microcontroller Basics by John H. Davies Elsevier; First edition (2010)
2. Computer as Components: Principles of Embedded Computing System Design, Wayne Wolf,2 nd edition,2008, Morgan Kaufmann Publication
3. ARM System on Chip Architecture by Steve Furber, Pearson Education

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| 13 | 16MTR41 | Group-1 | Programmable Logic Controllers (PLCs) |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module 1.**

**Technical Definition Of PLC**. What Are Its Advantages, Characteristic Functions Of A PLC,Chronological Evolution Of PLC, Types Of PLC, Unitary PLC, Modular PLC. Small PLC, .MediumPLC, ,LargePLC, Block Diagram Of PLC : Input / Output ( VO) Section, Processor Section, Power Supply, Memory. Central Processing Unit : Processor Software /Executive Software , Multitasking, Languages ,Ladder Language. Input And Output Contact Program Symbols , Numbering System Of Inputs And Outputs, Program Format

**Module 2.**

**Introduction To Logic**: Equivalent Ladder Diagram Of AND Gate, Equivalent Ladder Diagram Of OR Gate, Equivalent Ladder Diagram Of NOT Gate, Equivalent Ladder Diagram Of XOR Gate, Equivalent Ladder Diagram Of NAND Gate, Equivalent Ladder Diagram Of NOR Gate, Equivalent Ladder Diagram To Demonstrate De Morgan Theorem, Ladder Design. Timer And Its Classification: Characteristics Of PLC Timer, Functions in timer, Resetting Retentive And Non-Retentive, Classification Of PLC Timer, Or Delay And Off Delay 'Timers 'Timer-On Delay, Timer Off Delay , Retentive And Non-Retentive Timers, Format of a Timer Instruction.

**Module 3.**

**PLC Counter: Operation** Of PLC Counter, Counter Parameters, Counter Instructions Overview Count Up (CTU) Count Down (CTD).Introduction to Comparison Instructions, Discussions On Comparison Instructions, " EQUAL." or "EQU"Instruction, "NOT EQUAL" or "NEQ" Instruction, "LESS THAN" or "LES" Instruction, "LESS THAN OR EQUAL" or "LEQ" Instruction, GREATER THAN" or "GRT" Instruction, "GREATER THAN OR EQUAL TO" or "GRQ" Instruction » MASKED COMPARISON FOREQUAL" or "MEQ" Instruction, "LIMIT TEST" of "LIM" Instruction. Addressing Data Files- Format Of Logical Address, Addressing Format For Micrologic System.

**Module 4.**

**Data Movement Instructions**, Logical Instructions, Mathematical Instructions. Special Mathematical Instructions, Data Handling Instructions, Program Flow Control instructions Proportional Integral Derivative ( PID) Instruction. Introduction to Classification of I/O, I/O System Overview, Practical I/O System And Its Mapping Addressing Local And Expansion I/O, Input Output Systems, Direct f/O , Parallel I/O Systems Serial l/O Systems. Sinking And Sourcing, Discrete Input Module, Rectifier with Filter, Threshold Detection, Isolation, Logic Section Specifications Of Discrete input Module and Output Modules. Specifications Of Analog Input Module, Types Of Analog Input Module Special Input Modules, Analog Output Module, I/O Modules In Hazaradous Locations Power Supply Requirements, Power Supply Configuration, Filter

**Module 5.**

**Introduction: Evolution Of Industrial Control Process**, Types Of Communication Interface Types Of Networking Channels. Parallel Communication Interface, IEEE-488 Bus. Devices Useable with IEEE - 488, Handshaking Process, Interface Management Lines. Serial Communication Interface. Communication Mode, Synchronization And Timing In Communication, Synchronous And Asynchronous Transmissions Compared, Different Recommended Standards Compared Software Protocol, Industrial Network, Network Topology, Media Access Methods, Open System Interconnection (OSI) Network Model. Network Components, Advantage Of Standardized Industrial Network, Industrial Network, Controller Area Network (CAN), AS-I Interface, FOUNDATION FIELDBUS: Physical Layer ( Layer 1), Communication Stack (Layers 2 and 7), User Layer (Layer 8)Introduction to Utility Of Automation, General Structure Of An Automated Process, Examples Of Some Simple Automated Systems, Selection Of PLC, Introduction to various PLCs available in Seimens/Bosch. Exercise in industrial automation.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

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**Text Book**: '
PLC and Industrail Applications", MadhuchhandanGupts and SamarjitSen Gupta,
Pernram International Pub. (India) Pvt.Ltd., 2011.
**Reference Books:**
1. Cite Address :www.equinoxac.co.uk
2. 'Basic PLC Course(Programmiable Logic Controller)' , MohdShafiekYaacob, Pearson, 2006.
3. Cite Address: PLCs, ELOSTZ.com

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| 14 | 16MTR12 | Group-1 | FLUID POWER AUTOMATION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Fluid Power Generating/Utilizing Elements:** Hydrulic pumps and motor gears, vane, piston pumps-motors-selection and specification-drive characteristics-Linear actuator- Types, mounting details,cushioning-power packs-construction,reservoir capacity, heat dissipation, accumulators-standard circuit symbols, circuit (flow) analysis.

**Control and regulation elements:** Direction flow and pressure control valves-method of actuation,types,sizing of ports-pressure and temperature compensation, overlapped and under lapped spool valves-operating characterstics-electro hydraulic systems,electro hydraulic servo valves- different types characterstics and performance.

**Module 2**

**Comparison of Hydraulics and Pneumatics:** need for Automation, Hydraulic and Pneumatic comparision-ISO symbols for fluid power elements, Hydraulic,pneumatics-Selection criteria and examples related to selection criteria. Advanced Hydraulics: Types of proportional control devices-pressure relief, flow control, directional control, Hydraulic symbols, Spool configurations, electrical operation, Basic electrical circuit and operation, solenoid design, comparison between conventional and proportional valves

**Module 3**

**Method of control :** Comparison between analogue and digital contril, Proportional attributes, Ramp, Gain, dead band, Dither, Pulse width modulation, Amplifier cards, Principles of operation, Design and application, Analogue and digital, Closed loop, Internal and external feedback devices, Operation and application of closed loop system, Integrated electronics option frequency Response, Principles of operation, Bode diagrams and their use in manufacturer's data, PID control, Practical exercises, Commissioning and set up procedures, open loop circuits, closed loop circuits, Interface to the control.

**Module 4**

**Electrical Control of Fluid power:** Electrical control of Hydraulics and Pneumatics, use of relays, Timers, counters, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits, Electronic circuits for various open loop control and closed loop (Servo) control of Hydraulics and Pneumatics.

**Circuit Design:** Typical industrial hydraulic circuit design methodology- Ladder diagram-cascade, method-truth table- karnaugh map method-sequencing circuits- combinational and logiccircuit.

**Module 5**

**Application of Propositional and Servo Valves :** Velocity control, Position control and Directional control and applications example: paper industry, process industry, printing sawmill, wood working, extrusion press, power metallurgical press, continuous casting, Food and packaging, Injection moulding, Solar energy and automobile.

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**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. S.R.Majumdar-Pnematic System, TMH, 1995
2. Antony Esposito, Fluid Power Systems and Control, Prentice Hall,1998
3. R.Srinivasan, Hydraulic and Pneumatics control published by Vijay Nicole Imprints Private Ltd.
4. Andrew Parr, Hydraulic and Pneumatics, Butterworth-Heinemann


**References:**


1. Herbert R Merritt, Hydraulic control systems, John Wiely& Sons, Newyork,1967.
2. Dudbey A Peace, Basic fluid power, Prentice hall Inc,1967.
3. Peter Rohner, Fluid power logic circuit design, Macmillan press Ltd, London,1979.
4. Peter Rohner, Fluid Power logic circuit design, Mcmelan prem,1994.
5. Servo Pneumatics D Schilz A Zimmermann.

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| 01 | 16MCS11 | Group-2 | ADVANCED MATHEMATICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Introduction:** Numerical Analysis, Approximation errors-absolute and relative, round-off errors, round-off errors in arithmetical operations, Error in numerical method, Recursive Computation.

**Interpolation:** Problem of interpolation, Remainder or error in interpolation, Linear operators, Differences, difference table, Propagation of errors, Newton's forward interpolation formula, Newton's backward interpolation formula, Central interpolation, Stiriling's interpolation formula, Bessel's interpolation formula, Everett's interpolation formula, Steffensen's interpolation formula, Different interpolation zones, Error estimation, Working rules for use of different interpolation formulae, Sub-tabulation, Lagrange's interpolation formula, Aitken's interpolation method, Divided difference, Divided differences interpolation formula, Some important relations, Deductions from divided difference formula, Inverse interpolation, Estimate of remainder.

**Numerical Differentiation:** problem of numerical differentiation, Error term, Differentiation formulae for equidistant nodes, lagrange's differentiations formula.

**Numerical Integration:** Problem of numerical integration, A general formula, Some basic concepts, Newton-Cotes formula (closed type), Some lemmas, error in Newton-Cotes formula (closed type), Newton-Cotes formula (opened type), Some useful quadrature rules, Richardson extrapolation, Central- difference quadrature rules, Gaussian quadrature theory. Remarks on the use of different quadrature.

**Euler-Maclaurin Sum Formula**: Bernoulli polynomials, Euler-Maclaurin sum formula, Deductions of quadrature rules, Gregory- Newton quadrature formula, Romberg integration.

**Numerical Solution of Equations:** Introduction, Method of tabulation, Graphical method, Iteration proceses- basic concepts Method of bisection, Fixed-point iteration, Newton-Raphson method, Modified Newton-Raphson method, Inverse interpolation method, Secant method, Regula falsi method, Graeffe's method for algebraic equations.

**Numerical Solution of Linear Equations:** The problem and methods of solution, Gauss's elimination method, Iterative methods-preliminary concepts, Gauss-Jacobi iteration, Gauss-Seidel iteration, Ill- Conditioned equations.

**Numerical Solution of Differential Equations:** The problem. Basic concepts, Single-step methods-error and convergence, Euler's method, Runge-Kutta method, Multistep methods-general concepts, Methods for starting the solution, Adams-Bashforth method, Adams-Moulton method, Milne's method.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. Gupta A & Bose S C: **"Introduction to Numerical Analysis"** -Academic Publishers, 1989.
2. Hildebrand F B: **"Introduction to Numerical Analysis"** – Tata McGraw Hill, 1988.

**REFERENCE BOOKS:**

1. Conte S D and Carl de Boor: **"Elementary Numerical Analysis"-** McGraw Hill, 1980.
2. M K Jain, S R K Iyenger and Jain R K: **"Numerical Methods For Scientific & Engineering Com putation"** - New age international publishers.
3. Pervez Moin: **"Application Of Numerical Methods To Engineering"**
4. H K Dass: **"Advanced Engineering Mathematics"** - Chand and company Ltd., 12th edition.

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| 02 | 16MDE12 | Group-2 | FINITE ELEMENT METHOD |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**Module 1. Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and HeatTransfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, $C_o$ $C_1$ and $C_n$ Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. **10 Hours**

**Module 2. Solid Mechanics : One-Dimensional Finite Element Formulations and Analysis** – Bars- uniform, varying and stepped cross section-Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems. **10 Hours**

**Module 3. Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems **Three Dimensional Finite Element Formulations for Solid Mechanics Problems:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements. **10 Hours**

**Module 4. Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements. **10 Hours**

**Module 5. Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hours**

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**1.** T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
**2.** Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

**Reference Books:**

1. Rao S. S. , Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P. Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J. N. Reddy, Introduction to Finite Element Method, McGraw -Hill, 2006.
4. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006..
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

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| 03 | 16CAE13 | Group-2 | CONTINUUM MECHANICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Analysis of Stress:** Definition and Notation for forces and stresses. body force, surface force Components o stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses, maximum and minimum shea stress, Mohr's diagram in three dimensions. Boundary conditions .Stress components on an arbitrary plane, Stres invariants, Octahedral stresses, Decomposition of state of stress, deviator and spherical stress tensors, Stres transformation.

**Module 2. Deformation and Strain:** Deformation, Strain Displacement relations, Strain components, The state of strain at a point, , Principal strain, strain invariants, Strain transformation, Compatibility equations, Cubical dilatation, spherical and deviator strains, plane strain, Mohr's circle, and compatibility equation

**Relations and the General Equations of Elasticity:** Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity

**Module 3. Two Dimensional Problems in Cartesian Co-Ordinates:** Airy's stress function, investigation of simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.

**Module 4.** Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate.

**Thermal Stresses**: Introduction, Thermo-elastic stress -strain relations, thin circular disc, long circular cylinder

**Module 5. Torsion of Prismatic Bars:** Introduction, Torsion of Circular cross section bars, Torsion of elliptical cross s bars, Soap film analogy, Membrane analogy, Torsion of thin walled open tubes.

**Elastic Stability**: Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section. **Viscoelasticity**: Linear viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals. Complex moduli and compliances. (Note: No numerical)

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1 Timoshenko and Goodier, "**Theory of Elasticity**"-'Tata McGraw Hill, New Delhi,3rd edition , 1970
2. L S Srinath "Advanced Mechanics of Solids"- Tata McGraw Hill, New Delhi, 3rd edition, 2010
3. G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press,Boca Raton, 2010


**References:**


1. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006.
2. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970
3. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press , 2006.
4. Sadhu Singh," Theory of Elasticity"- Khanna publisher, 4th edition, 2013

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| 04 | 16CAE14 | Group-2 | EXPERIMENTAL MECHANICS |
|---|---|---|---|

Exam Hours:03 | Exam Marks:100

**Module 1. Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

**Analysis of Experimental Data:** Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

**Module 2. Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

**Force, Torque and Strain Measurement:** Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage

**Module 3. Stress Analysis:** Two Dimensional Photo elasticity - Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, IsoclinicsIso chromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling**.**

**Module 4. Three Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.**

**Module 5. Coating Methods:** a) Photoelastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photoelastic strain gauges. b) Brittle Coatings Method:Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach- sensitivity of Moire data data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

**Holography:** Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holograpicinterferomerty, Realtime. and double exposure methods, Displacement measurement, Isopachics.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. **Holman,**"Experimental Methods for Engineers" 7th Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** "Mechanical measurements" New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement And Analysis -**Nakra&Chaudhry, B C Nakra K KChaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.


**Reference Books:**


1. **Measurement Systems Application and Design** - Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **PhotoelasticityVol I and Vol II -** M.M.Frocht,. John Wiley and sons, 1969.
6. **Strain Gauge Primer** - Perry and Lissner, McGraw Hill, 1962.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 05 | 16MDE151 | Group-2 | COMPUTER GRAPHICS |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**Module 1. Transformations :** Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line, Rotation about an axis parallel to coordinate axis, Rotation about an arbitrary axis in space, Reflection through an arbitrary plane.

**Module 2. Types and Mathematical Representation of Curves:** Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, , Bezier curves: Blending function, Properties, generation, B-spline curves- Cox-deBoor recursive formula, Properties, Open uniform basis functions, Non-uniform basis functions, Periodic B-spline curve.

**Types and Mathematical Representation of Surfaces** Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface.

**Module 3. Types and Mathematical Representation of Solids:** Solid entities: Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.

**Scan Conversion and Clipping:** Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hodgmen algorithm

**Module 4. Visual Realism:** Introduction, Hidden line removal, Visibility of object views, Visibility techniques: Minimax test, Containment test, Surface test, Silhouttes, Homogeneity test, Sorting, Coherence, Hidden surface removal-Z-buffer algorithm, Warnock's algorithm, Hidden solid removal - ray tracing algorithm, Shading, Shading models, Diffuse reflection, Specular reflection, Ambient light, Shading of surfaces: Constant shading, Gourand shading, Phong shading, Shading enhancements, Shading Solids, Ray tracing for CSG, Z-buffer algorithm for B-rep and CSG

**Module 5. Applications:** Colouring- RGB, CMY, HSV, HSL colour models, Data Exchange: Evolution of Data exchange, IGES, PDES, Animation: Conventional animation-key frame, Inbetweening, Line testing, Painting, Filming, Computer animation, Entertainment and Engineering Animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom-pan-scroll, Cross bar, Real time play back, Animation techniques-key frame, Skelton. Path of motion and p-curves.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TextBooks:**


1. IbrahamZeid, CAD/CAM-Theory and Practice-McGraw Hill, 2006.
2. David Rogers & Alan Adams, Mathematical Elements for Computer Graphics-Tata McGraw Hill, 2002.


**ReferenceBooks:**


1. Xiang Z, Plastock, R. A, Computer Graphics- Schaum's Outline, McGraw Hill, 2007.
2. Foley, van Dam, Feiner and Hughes, Computer Graphics- Principles and Practice-Addison Wesley, 1996.
3. Sinha A N., Udai A D., Computer Graphics- Tata McGraw Hill, 2008.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 06 | 16MST22 | Group-2 | SMART MATERIALS AND STRUCTURES |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.

**Beam Modeling:** Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

**Module 2. Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems.

**ER and MR Fluids:** Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response. Post-Yield flow applications in Clatches, Dampers and Others.

**Module 3. Vibration Absorbers:** series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications.

**Control of Structures:** Modeling, Control Strategies and Limitations, Active Structures in Practice.

**Module 4. MEMS** – Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

**Module 5. Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS :**

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

**REFERENCE BOOKS:**

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer,
Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

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| 07 | 16MAR156 | Group-2 | MODERN CONTROL ENGINEERING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Introduction to Automatic Controls:** Representation of Control Components, Representation of Control Systems, Characteristic functions, Steady-State Operation, Laplace Transforms, Basic Control Actions and Industrial Automatic Controllers 10 Hours

**MODULE 2**

**The Root-Locus Method:** -Introduction, Root Locus Plots, Illustrations, General rules for Constructing Root Loci, Root Locus Analysis of Control Systems, Transport Lag and Root contour Plots 10 Hours

**MODULE 3**

**Frequency Response Methods:-** Introduction, Frequency Response, Logarithmic Representation, Evaluating the Gain K, Equivalent Unity-Feedback Systems. Polar Plots, M And Circles, Correlation between Transient and Frequency Response. 10 Hours

**MODULE 4**

**System Compensation:** Nyquist Stability Criterion, Gain Margin and Phase Margin, Lead Compensation, Lag Compensation, Lag-Lead Compensation.

**State-Space Methods: -** Introduction, Basic materials in State-Space Analysis, Transfer Matrices, Controllability, Observability, System Representation, Signal Flow Graphs, Solution of State-Space Equations. 10 Hours

**MODULE 5**

**Control Action and System Compensation:** Concept of proportional, integral, proportional integral, proportional-integral- differential controllers, series and feedback compensation, Physical devices for system compensation.

**Introduction to State Variable Techniques:** Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalman and Gilberts test. 10 Hours

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. Automatic Control Engineering - Francis H. Raven, McGraw- Hill International.
2. Modern Control Engineering - K. Ogata, PHI.


**Reference Books:**


1. Automatic Control Systems - B.C. Kuo, Prentice hall.
2. Automatic Control Systems - Harrison & Bollinger, International Text Book Company.
3. Feed Back Control System -Schaum's Series, McGraw Hill.
4. Control Systems -Gopal, McGraw Hill.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 08 | 16CAE421 | Group-2 | FRACTURE MECHANICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Fracture mechanics principles:** Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems.

**MODULE 2**

**Plasticity effects:** Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test. Size requirements. Non-linearity. Applicability.

**MODULE 3**

**the energy release rate:** Criteria for crack growth. The crack resistance(R curve). Compliance, J integral. Tearing modulus. Stability. Elastic plastic fracture mechanics : Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral.

**MODULE 4**

**Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness

**MODULE 5**

**Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1.David Broek, "Elementary Engineering Fracture Mecha nics", Springer Netherlands,2011
2.Anderson , "Fracture Mechanics-Fundamental and Appl ication", T.L CRC press1998.

**Reference Books:**

1.Karen Hellan , "Introduction to fracture mechanics" , McGraw Hill, 2nd Edition
2.S.A. Meguid , "Engineering fracture mechanics" Else vier Applied Science, 1989
3.Jayatilaka, "Fracture of Engineering Brittle Mater ials", Applied Science Publishers, 1979
4.Rolfe and Barsom , "Fracture and Fatigue Control in Structures" , Prentice Hall, 1977
5.Knott , "Fundamentals of fracture mechanisms", But terworths, 1973

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 09 | 16MDE22 | Group-2 | ADVANCED MACHINE DESIGN |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory. Numerical examples.

**Fatigue of Materials:** Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

**Module 2. Stress-Life (S-N) Approach:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S- N approach.

**Strain-Life(ε-N)approach:** Monotonic stress-strain behavior ,Strain controlled test methods ,Cyclic stress-strain behavior ,Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

**Module 3. LEFM Approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation.

**Notches and their effects**: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean Stress effects and Haigh diagrams, Numerical examples.

**Module 4. Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. Numerical examples.

**Notch strain analysis:** Strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches. Numerical examples.

**Module 5. Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear.

**Surface fatigue**: spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength, Surface fatigue failure modes, Design to avoid Surface failures.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, "Metal Fatigue in engineering", John wileyNewyork, Second edition. 2001.
2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992.
3. Robert L. Norton , "Machine Design", Pearson Education India, 2000

**Reference Books:**

1. S.Suresh , "Fatigue of Materials", Cambridge University Press, -1998
2. Julie.A.Benantine , "Fundamentals of Metal Fatigue Analysis", Prentice Hall,1990
3. Fatigue and Fracture, ASM Hand Book, Vol 19, 2002.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 10 | 16MCM 422 | Group-2 | DYNAMICS AND MECHANISM DESIGN |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method**.**

**Module 2**

**Generalized Principles of Dynamics:** Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples. Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle.

**Module 3**

**System Dynamics:** Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation.

**Module 4**

**Graphical Methods of Dimensional Synthesis:** Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples.

**Module 5: Spatial Mechanisms:** Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


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


**References Books:**


1. J E Shigley, “Theory of Machines and Mechanism” -M cGraw-Hill, 1995
2. A.G.Ambekar , “Mechanism and Machine Theory”, PHI, 2007.
3. Ghosh and Mallick , “Theory of Mechanism and Mechan ism”, East West press 2007.
4. David H. Myszka , “Machines and Mechanisms”, Pearso n Education, 2005.

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| 11 | 16MMD41 | Group-2 | TRIBOLOGY AND BEARING DESIGN |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

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

**Module 2 Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow.Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems 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.

**Module 3 Hydrostatic Bearings:** Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant.Grubin type solution.

**Module 4 Antifriction bearings:** Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival,equivalent load, cubic mean load, bearing mountings.Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings,Equations for porous bearings and working principal, Fretting phenomenon and its stages.

**Module 5**

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

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**


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


**Reference Books**


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

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| 12 | 16MDE24 | Group-2 | ADVANCED THEORY OF VIBRATIONS |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module 1. Review of Mechanical Vibrations**: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
**Vibration Control**: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers, and Vibration dampers.

**Module 2. Vibration Measurement and applications**: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.
**Modal analysis & Condition Monitoring**: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.

**Module 3. Transient Vibration of single Degree-of freedom systems**: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.
**Random Vibrations:** Random phenomena Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response.

**Module 4. Non Linear Vibrations**: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.

**Module 5. Continuous Systems**: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

1. S. S. Rao, "Mechanical Vibrations", Pearson Education, 4th edition.
2. S. Graham Kelly, "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education.

**Reference Books**

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha, "Vibraitons and Acoustics – Measurements and signal analysis", Tata McGraw Hill, 2010.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 13 | 16MDE254 | Group-2 | ROTOR DYNAMICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.

**Stability of Flexible Shafts:** Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.

**MODULE 2**

**Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center

**MODULE 3**

**Turborotor System Stability by Transfer Matrix Formulation:** General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.

**MODULE 4**

**Turborotor System Stability by Finite Element Formulation:** General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis.

**MODULE 5**

**Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


1. Cameron, “Principles of Lubrication”, Longman Publishing Group, 1986
2. Bolotin , “Nonconservative problems of the Theory of elastic stability”, Macmillan, 1963
3. Peztel, Lockie , “Matrix Methods in Elasto Mechanics”, McGraw-Hill, 1963.
4. Timosenko , “Vibration Problems in Engineering”, Oxford City Press, 2011
5. Zienkiewicz, “The finite element method in engineering science”, McGraw-Hill, 1971

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 14 | 16MTR254 | Group-2 | EXPERIMENTAL TECHNIQUES |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction –** Multivariate analysis, the variate, measurement scales, measurement error and multivariate measurement, types of multivariate techniques, multiple regression, multivariate analysis of variance and covariance.

**Module 2. A structured approach to multivariate model building –** define the research problem, objectives and multivariate technique to be used, develop the analysis plan, evaluate the assumptions underlying the technique, estimate the multivariate model and assess the model fit, interpret the variate, validate the model.
**Examining the data –** graphical examination of the data, Missing data, approaches to dealing with missing data.

**Module 3. Factor Analysis –** Objectives of factor analysis, designing a factor analysis, assumptions in factor analysis, deriving factors and assessing overall fit, interpreting the factors and validation of factor analysis.

**Module 4. Multiple Regression Analysis –** Objectives of multiple regressions, research design, assumptions, estimating the regression model, assessing fit, interpretation and validation.
**Multiple Discriminant Analysis and Logistic Regression –** Decision process for discriminant analysis, Objectives, Research design, assumptions, model estimation, interpretation and validation of results.

**Module 5. Interdependence Techniques –** Cluster Analysis – Objectives, research design, assumptions, deriving clusters and assessing fit, interpretation and validation.
**Multidimensional scaling –** Objectives of MDS, Research design, assumptions, deriving the solution and assessing overall fit, interpreting and validating the results.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Multivariate Data Analysis – Hair, Anderson, Tatham, Black, Fifth Edition, Pearson Education, 2003.
2. Discrete multivariate analysis – Bishop Y M, Fienberg S. E. and Holland P. W. (1975), Cambridge, Mass: MIT Press
3. Applied Regression Analysis – Norman R. Draper, H Smith, Wiley Interscience ISBN: 0471171028
Recommended software: SPSS, Systat 10.2

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 01 | 16MTP13 | Group-3 | ADVANCED FLUID MECHANICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction and Kinematics of Fluids:** Concepts of continuum rarefied gas dynamics, magneto fluid mechanics regimes in mechanics of fluids; fluid properties. **Kinematics of Fluids**- Methods of describing fluid motion - Lagrangian method, Eulerian method; translation, rotation and rate of deformation; stream lines, path lines and streak line; material derivative and acceleration; vorticity.

**Governing Equations for Fluid Flow**: Nature of stress; transformation of stresses - nature of strains; transformation of the rate of strain; relation between stress and rate of strain; Conservation equations for mass, momentum and energy - differential and integral forms; Euler's equations of motion, integration along the stream line; integration of steady irrotational motion; integration for two dimensional unsteady flow.

**Module 2. Mechanics of Laminar Flow**: Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number – wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus.

**Mechanics of Turbulent Flow**: Structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equationmodel for fully turbulent flows; k-l, k- and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.

**Module 3. Exact and Approximate solutions of N-S Equations**: Introduction; Parallel flow past a sphere; Oseen's approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow.

B**oundary Layer Theory**: Introduction; Boundary layer equations; displacement and momentum thickness, shape factor; flow over a flat plate – similarity transformation, integral equation for momentum and energy ; skin friction coefficient and Nusselt number; separation of boundary layer; critical Reynolds number; control of boundary layer separation.

**Module 4. Flow Around bodies:** Introduction; flow past a circular cylinder; drag on a sphere; stream lined body, lift and drag on airfoil; Drag and lift on road vehicles.

**Module 5. Experimental Techniques**: Introduction; improved modeling through experiments; design of fluid flow experiments; error sources during measurement; pressure transducers; hot wire anemometer; laser - Doppler velocity meter; methods of measuring turbulence fluctuations - flow visualization techniques; wind tunnel; analysis of experimental uncertainty - types of error, estimation of uncertainty.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. **Foundations of fluid mechanics -** S.W. Yuan, Prentice Hall of India, 1976.
2. **Engineering Fluid Mechanics -** P.A. AswathaNarayana& K.N. Seetharamu, Narosa publications, 2005.

**Reference Books:**

3. **Fluid Mechanics -** F.M. White, McGraw-Hill publications.
4. **Advanced fluid mechanics -** K. Muralidhar and G. Biswas, Narosa publications, 1996.
5. **Introduction to fluid dynamics - Principles of analysis & design -** Stanley Middleman, Wiley, 1997.

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| 02 | 16MTP14 | Group-3 | Thermodynamics &Combustion Engineering |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1.** Work and heat interaction, first law of thermodynamics, steady and unsteady flows with energy transaction. Second law of thermodynamics, reversibility, corollaries of the second law and entropy. Available energy, availability analysis of open and closed systems.

**Module 2.** Properties of pure substances, properties of gases and gas mixtures, combined first and second laws of thermodynamics. Phase and reaction equilibrium, equilibrium constants, calculation of equilibrium composition of multi component gaseous mixtures.

**Module 3.** Equation of state and calculation of thermodynamics and transport properties of substances. Reaction rates and first, second and higher order reaction, in gaseous, liquid and solid phases.

**Module 4.** Combustion and flame velocities, laminar and turbulent flames, premixed and diffusion flames, their properties and structures.

**Module 5.** Theories of flame propagation, thermal, diffusion and comprehensive theories, problems of flame stability, flashback and blow off. Combustion of solid, liquid and gaseous fuels. Combustion of fuel droplets and sprays. Combustion system combustion in closed and open systems, application to boiler, gas turbine combustors and rocket motors.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. **Engineering Thermodynamics -** P.K. Nag, Tata McGraw-Hill Publications.
2. **Fundamentals of Classical Thermodynamics -** G. Van Wylen and R.E. Sonntag, Wiley, 1986.

**Reference Books:**

1. **Energy. Combustion and Environment -** N.A. Chigier, McGraw-Hill, 1981.
2. **Introduction to combustion phenomena -** A. Murthy Kanury, Gordon and Breach, 1975.
3. **Fuels and combustion -** S.P. Sharma and Chandra Mohan, Tata McGraw-Hill, 1984.
4. **Engineering Thermodynamics -** Onkar Singh. New age International Publications.

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| 03 | 16MTP151 | Group-3 | Non Conventional Energy System |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Global and National Energy Scenario:** Over view of conventional & renewable energy sources – Need & development of renewable energy sources - Types of renewable energy systems - Future of Energy Use - Global and Indian Energy scenario -Renewable and Non-renewable Energy sources, Energy for sustainable development - Potential of renewable energy sources - Renewable electricity and key elements – Global climate change - CO2 reduction potential of renewable energy- Concept of Hybrid systems.

**Module 2. Solar Energy:** Solar energy system - Solar Radiation – Availability - Measurement and Estimation – solar Thermal Conversion Devices and Storage - Applications Solar Photovoltaic Conversion - solar thermal - Applications of solar energy systems.

**Module 3. Wind Energy:** Wind Energy Conversion – Potential - Wind energy potential measurement – Site selection - Types of wind turbines - Wind farms - Wind Generation and Control - Nature of the wind - Power in the wind - Factors influencing wind – Wind data and energy estimation - Wind speed monitoring - Classification of wind –Characteristics - Applications of wind turbines - Offshore wind energy – Hybrid systems -Wind resource assessment - Betz limit - Site selection - Wind energy conversion devices- Wind mill component design - Economics and demand side management – Energy wheeling - Energy banking
concepts - Safety and environmental aspects - Wind energy potential and installation in India.

**Module 4. Biogas:** Properties of biogas (Calorific value and composition) - Biogas plant technology and status – Bio energy system - Design and constructional features – Biomass resources and their classification – Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification – pyrolysis and liquefaction -biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion – Biomass energy programme in India

**Module 5. Ocean Energy**: Ocean wave energy conversion - Principle of Ocean Thermal Energy Conversion (OTEC) - Ocean thermal power plants - Tidal energy conversion - Tidal and wave energy its scope and development - Scheme of development of tidal energy.
**Geothermal power plants -** Various types - Hot springs and steam ejection.
**Fuel cells:** Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cells.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING:**

1. B.H.Khan, Non conventional Energy Resources, Tata McGraw Hill, New Delhi, 2012
2. Non-Conventional Energy Sources G.D Rai,Khanna Publishers, 2004
3. S.Rao and B.B.Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2010
4. S.P.Sukhatme and J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2008
5. J.A.Duffie and W.A.Beckman, Solar Energy Thermal Processes, John Wiley, 2010

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| 04 | 16MTP154 | Group-3 | REFRIGERATION AND AIR CONDITIONING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Refrigeration cycles** – analysis: Development of Vapor Compression Refrigeration Cycle from Reverse Carnot Cycle- conditions for high COP-deviations from ideal vapor compression cycle, Multi-pressure Systems, Cascade Systems-Analysis.

**Main system components:** Compressor- Types , performance , Characteristics of Reciprocating Compressors, Capacity Control, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load.

**Module 2. Refrigerants:** Classification of Refrigerants, Refrigerant properties, Oil Compatibility, Environmental Impact-Montreal/ Kyoto protocols-Eco Friendly Refrigerants. Different Types of Refrigeration Tools, Evacuation and Charging Unit, Recovery and Recycling Unit, Vacuum Pumps.

**Other refrigeration cycles**: Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.

**Module 3. Psychometric:** Moist Air properties , use of Psychometric Chart , Various Psychometric processes , Air Washer , Adiabatic Saturation. Summer and winter air conditioning:

Air conditioning processes-RSHF, summer Air conditioning, Winter Air conditioning, Bypass Factor. Applications with specified ventilation air quantity- Use of ERSHF, Application with low latent heat loads and high latent heat loads.

**Module 4. Load estimation & air conditioning control:** Solar Radiation-Heat Gain through Glasses, Heat transfer through roofs and walls, Total Cooling Load Estimation. Controls of Temperature, Humidity and Air flow.

**Module 5. Air distribution:** Flow through Ducts , Static & Dynamic Losses , Air outlets , Duct Design–Equal, Friction Method , Duct Balancing , Indoor Air Quality , Thermal Insulation , Fans & Duct System Characteristics , Fan Arrangement Variable Air Volume systems , Air Handling Units and Fan Coil units.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited 2002
2. Arora C.P., Refrigeration and Air-conditioning, 3rdedition,Tata McGraw –Hill, New Delhi 2008
3. Stoecker W.F., and Jones J.W., Refrigeration and Air-conditioning, 2nd edition McGraw - Hill, New Delhi
4. Data Books: Refrigerant and Psychrometric Properties (Tables & Charts) SI Units, Mathur M.L. & Mehta F.S., Jain Brothers. 2010.
5. Principles and Refrigeration- Goshnay W.B., Cambridge, University Press, 1985.
6. Solid state electronic controls for HVACR' -Langley, Billy C., 'Prentice-Hall 1986
7. Refrigeration and Air Conditioning- Arora C.P., Tata McGraw Hill Pub. Company
8. Handbook of Air Conditioning Systems design- Carrier Air Conditioning Co., McGraw Hill,
9. Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.
10. Fundamentals and equipment- 4 volumes-ASHRAE Inc. 2005.
11. Air Conditioning Engineering-Jones, Edward Amold pub. 2001.

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| 05 | 16MTP41 | Group-3 | DESIGN OF HEAT TRANSFER EQUIPMENT FOR THERMAL POWER PLANT |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**CLASSIFICATION OF HEAT EXCHANGERS:** Introduction, Recuperation & regeneration, Tabular heat exchangers, Double pipe, shell & tube heat exchanger, Plate heat Exchangers, Gasketed plate heat exchanger. Spiral plate heat exchanger, Lamella heat exchanger, Extended surface heat exchanger, Plate fin and Tabular fin. Basic Design Methods of Heat Exchanger: Introduction, Basic equations in design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis, Parallel flow, Counter flow. Multipass, cross flow heat exchanger design calculations.

**Module 2**

**DOUBLE PIPE HEAT EXCHANGER:** Film coefficient for fluids in annulus, fouling factors, Calorific temperature, Average fluid temperature, The calculation of double pipe exchanger, Double pipe exchangers in series parallel arrangements. Shell & Tube Heat Exchangers: Tube layouts for exchangers, Baffle heat exchangers, Calculation of shell and tube heat exchangers, Shell side film coefficients, Shell side equivalent diameter, The true temperature difference in a 1-2 heat exchanger. Influence of approach temperature on correction factor. Shell side pressure drop, Tube side pressure drop, Analysis of performance of 1-2 heat exchanger and design of shell & tube heat exchangers, Flow arrangements for increased heat recovery, the calculation of 2-4 exchangers

**Module 3**

**CONDENSATION OF SINGLE VAPOURS:** Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam

**Module 4**

**VAPORIZERS, EVAPORATORS AND REBOILERS:** Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger

**Module 5**

**DIRECT CONTACT HEAT EXCHANGER:** Cooling towers, relation between wet bulb & dew point temperatures, The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Deign of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING**

1.James R. Couper; W. Roy Penney, James R. Fair, Stanley M. Walas, Chemical Process Equipment: selection and design, Elsevier Inc., 2nd ed. 2005
2.1.Process heat transfer- Donald Q.Kern, Tata McGraw Hill Publishing Company Ltd.
3.Heat Exchangers Selection, Rating and Thermal Design- SadikKakac and Hongtan Liu, CRC Press.
4.Process Heat Transfer- Sarit K.Das, Narosa Publishing House Pvt. Ltd.
5.Standards of the Tubular Exchange Manufacturers Association, TMEA, New York.
6.Heat exchanger design- Press and N. Ozisik.
7.Heat Exchangers- Kakac, S., A.E. Bergles and F. Mayinger (Eds.) Hemisphere, 1981.
8. Compact Heat exchangers- Kays, W.M., and A.L. London, McGraw Hill.

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| 06 | 16MCS154 | Group-3 | SOLAR ENERGY ENGINEERING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Introduction:** Man and energy, World's production and reserves of commercial energy sources, India's production and reserves, Energy alternative. The Solar Energy option- an overview of Thermal Applications,Devices, for thermal collection and storage, Thermal application, Some observations.

**Solar Radiation:** Solar radiation outside the earth's atmosphere, Solar radiation at the earth's surface, Instruments for measuring solar radiation and sunshine, solar radiation data, solar radiation geometry, Empirical equations for predicting the availability of solar radiation, solar radiation on tilted surfaces,

**MODULE 2**

**Liquid Flat Plate Collectors:** Performance analysis, Transmissivity of cover system, Transmissivity-absrptivity product , Overall loss coefficient and heat transfer correlations, Collector efficiency factor, collector heat-removal factor, A numerical example, Effects of various parameters on performance , Analysis of collectors similar to the conventional collector, Transient analysis, testing procedures, Alternatives to the conventional collector.

**MODULE 3**

**Solar Air Heaters:** Performance analysis of a conventional air heater, other types of air heaters, Testing procedures.

**Concentrating Collectors:** Flat-plate collectors with plane reflectors, cylindrical parabolic collector, Compound Parabolic collector (CPC), Paraboloid dish collector, central receiver collector.

**MODULE 4**

**Thermal Energy Storage:** Sensible heat storage, Latent heat storage, Thermo chemical storage. Solar Pond, Description, Performance analysis, Experimental studies Operational problems, Other solar pond concepts

**MODULE 5**

**Economic Analysis:** Initial and annual costs, Definitions, Present worth calculation, Repayment of loan in equal annual instalments, Annual Solar savings, Cumulative solar savings and life cycle savings, Payback period, Concluding remarks.

**Other Methods for Solar Energy Utilization**: Photovoltaic conversion, Wind energy, Energy from biomass, Wave energy, Ocean thermal energy conversion, Geothermal Energy.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1.S P Sukhatme: "Solar Energy "- Tata McGraw-Hill publishing company limited New Delhi, 1996
2.H P Garg and J Prakash:" Solar Energy Fundamentals"

**REFERENCE BOOKS:**

1.D .Yogi Goswami, F. Kreith and J. F.Kreider: "Principles of Solar Engineering "- published by Taylor & Francis-2000
2.A.B. Meinel and F.P. Meinel,: "Applied Solar Energy" - Addison-Wesley, 1976.
3.J.A. Duffie and W. A. Beckman C:"Solar Engineering of Thermal Processes" - John Wiley & Sons, 1991

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| 07 | 16MTP252 | Group-3 | Alternate Fuels for IC Engines |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Conventional Fuels:** Introduction, Current fuel scenario and consumption, per capita consumption Indian scenario, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI enginefuels, Octane number requirement, Diesel fuels.

**Properties of petroleum products:** Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloudpoint, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

**Module 2**

**Alternative fuels for I.C. engines:** Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas andtheir methods of manufacturing.

**Single Fuel Engines:** Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance andemission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.

**Module 3**

**Dual fuel Engine:** Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuelengine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.

**Module 4**

**Bio-diesels:** What are bio-diesels Need of bio-diesels, Properties of bio-diesels v/s petro-diesel, Performance and emission characteristics ofbio-diesels v/s Petro diesel operation.

**Availability:** Suitability & Future prospects of these gaseous fuels in Indian context.

**Module 5**

**Environmental pollution:** with conventional and alternate fuels, Pollution control methods and packages.Euro norms , Engineemissions, Emission control methods, EPA. Air quality emission standards

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


- A Course in Internal Combustion Engines - R.P Sharma & M.L. Mathur, DanpatRai& Sons.
- Elements of Fuels, Furnaces & Refractories - O.P. Gupta, Khanna Publishers
- Internal Combustion Engines -Domkundwar V.M., I Edition, DhanpatRai& Sons.
- Internal Combustion Engines Fundamentals - John B. Heywood, McGraw Hill International Edition.
- Present and Future Automotive Fuels - Osamu Hirao& Richard Pefley, Wiley Interscience Publications.
- Internal Combustion Engines - V. Ganesan, Tata McGraw-Hill Publications.

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| 08 | 16MTP421 | Group-3 | CONVECTIVE HEAT AND MASS TRANSFER |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**INTRODUCTION TO FORCED, FREE & COMBINED CONVECTION –** convective heat transfer coefficient – Applicationof dimensional analysis to convection – Physical interpretation of dimensionless numbers.Equations of Convective Heat Transfer: Continuity, Navier-Strokes equation & energy equation forsteady state flows – similarity – Equations for turbulent convective heat transfer – Boundary layerequations for laminar, turbulent flows – Boundary layer integral equations

**Module 2**

**EXTERNAL LAMINAR FORCED CONVECTION:** Similarity solution for flow over an isothermal plate– integral equation solutions – Numerical solutions – Viscous dissipation effects on flow over a flatplate.External Turbulent Flows: Analogy solutions for boundary layer flows – Integral equation solutions Effects of dissipation on flow over a flat plate.Internal Laminar Flows: Fully developed laminar flow in pipe, plane duct & ducts with other crosssectionalshapes – Pipe flow & plane duct flow with developing temperature field – Pipe flows & planeduct flow with developing velocity & temperature fields.Internal Turbulent Flows: Analogy solutions for fully developed pipe flow –Thermally developingpipe & plane duct flow

**Module 3**

**NATURAL CONVECTION:** Boussineq approximation – Governing equations – Similarity – Boundarylayer equations for free convective laminar flows – Numerical solution of boundary layer equations.Free Convective flows through a vertical channel across a rectangular enclosure – Horizontalenclosure – Turbulent natural convection

**Module 4**

**COMBINED CONVECTION:** Governing parameters & equations – laminar boundary layer flow overan isothermal vertical plate – combined convection over a horizontal plate – correlations for mixedconvection – effect of boundary forces on turbulent flows – internal flows - internal mixed convectiveflows – Fully developed mixed convective flow in a vertical plane channel & in a horizontal duct

**Module 5**

**CONVECTIVE HEAT TRANSFER THROUGH POROUS MEDIA**: Area weighted velocity – Darcy flowmodel – energy equation – boundary layer solutions for 2-D forced convection – Fully developed ductflow – Natural convection in porous media – filled enclosures – stability of horizontal porous layers.

**CONVECTIVE MASS TRANSFER:** Basic Definitions and Formulation of a Simplified Theory, Evaluation of The Mass-Transfer Conductance, Examples for application of the Simplified Method

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

**READING:**

1.Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2.Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, New York, 2001.

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| 09 | 16MTP422 | Group-3 | ENGINE FLOW AND COMBUSTION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Gas exchange process:** Inlet & exhaust processes in four stroke cycle, volumetric efficiency, flow through valves, residual gas fraction,exhaust gas flow rate and temperature variation, super charging, turbo charging.Intake jet flow, mean velocity turbulence characteristics, swirl, squish, pre chamber engine flows, creviceflow and blow by, flows generated by piston cylinder wall interaction

**Module 2**

**Combustion in IC Engines:** Combustion in SI engines: Ignition, flame velocity, Normal andabnormal combustion, knocking, pre-ignition, effect of engine variables on knocking, featuresand design consideration of combustion chambers, concept of lean burn engines, Combustion inCI engines: Air motion: Swirl and squish, spray formation and vaporization, Stages ofcombustion, physical and chemical delay, diesel knock, effect of engine variables on dieselknock, combustion chambers: design features, Combustion characteristics of Biodiesel andBiodiesel blends, Low NOx diesel combustion: homogeneous charge compression ignitionengine (HCCI- combustion), pHCCI, and EGR techniques10Hours

**Module 3**

**Combustion Models:** Fuel spray: Factors influencing fuel spray atomization, Spray equationmodels, penetration and dispersion of fuel, fuel line hydraulics, fuel pumps and injectors, Zerodimensional modeling, quasi dimensional modeling, combustion systems: efficiency and itsapplications, Single zone models, multi zone models, Premixed and diffusive models, Heattransfer coefficients, and specific heat relations, Weibes function analysis, two zone models, heattransfer in IC engines, heat transfer correlations, data logging and acquisition, cylinder-pressuremeasurement and Gross and net release rate calculations.

**Module 4**

**Engine Emissions and Air-Pollution:** Emissions and its Formation: Gaseous emissions: CO,CO2, HC, NOx (NO & NO2), SOx (SO2 & SO3); particulate matter (PM), Sources of emissionformation; Emissions formation mechanisms of PM and NOx; volatile organic compounds(VOCs), poly aromatic hydrocarbons (PAH), soluble organic fraction (SOF); Mechanism of airpollution: Ozone depletion, Greenhouse effect, Photochemical smog, acid rain, Effect of airpollutionon health and environment, Emission norms (passenger and commercial vehicles):National and International emission standards: BS-III and BS-IV & Euro III, IV, and V

**Module 5**

**Emission Control Technologies and Emission Measurements:** PM reduction technologies:Diesel oxidation catalysts (DOCs), Diesel particulate filters (DPFs), closed crankcase ventilation(CCV); NOx reduction technologies: Exhaust gas recirculation (EGR), Selective catalyticreduction (SCR), Lean NOx catalysts (LNCs), Lean NOx traps (LNTs), NOx adsorber catalysts,Exhaust gas recirculation (EGR), Diesel exhaust after treatment: diesel oxidation catalyst (DOC), diesel particulate filter (DPF), Soot suppression by fuel additives, relationship: soot, combustionchamber and swirl ratio, catalytic convertors: constructional features and types: 2-way and 3-way catalytic convertors. Measurement of gaseous emissions using thermal, chemical, magneticand optical gas analyzers: infrared gas analyzer, chemiluminescent analyzer, gaschromatography, smoke (soot) measurement, application of microprocessor in emission control.Trends of emission reduction

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**BOOKS:**


1Combustion Modeling in Reciprocating Engines, by James N Mattavi and Charles A Amann, Plenum press, 1980
2. Thermodynamic Analysis of Combustion Engines, by Ashley S Campbell, John Wiley and Sons, 1980
3. Internal Combustion Engines and Air Pollution, by Edward .F Obert, Intext Education Publishers, 1980
4. Automotive Emission Control , Crouse William, Gregg division, McGraw-Hill,
5. Internal Combustion Engine Fundamentals, John B. Heywood, Tata McGraw-Hill,1998
6. Internal combustion engine modeling, by J I Ramos, Hemisphere Publishing Corporation, 1989

7. Experimental Methods for Engineers by Holman J. P, McGraw-Hill,1988
8.Computer Simulation of Spark Ignition Engine Processes, by Ganesan V., University press, 1995

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| 10 | 16MTP423 | Group-3 | DESIGN & ANALYSIS OF THERMAL SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Thermal Systems:** Characteristics- formulation of design problem - Steps in the designprocess - Modeling of thermal systems – importance - Types of models – MathematicalModeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power

**Module 2**

**Design of piping and pump systems:-** Head loss representation ;Piping networks ; Hardy – Cross method Generalized Hardy – Crossanalysis ; Pump testing methods ; Cavitation considerations ; Dimensional analysis of pumps ; piping system design practice.

**Module 3**

**Unconstrained Optimization Techniques:** Univariate, Conjugate Gradient Method and Variable Metric Method. Constrained Optimization Techniques: Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions

**Module 4**

**Thermo-economic analysis and evaluation:-** Fundamentals of thermo-economics, Thermo-economic variables for component evaluation ;thermo-economic evaluation ; additional costing considerations.

**Module 5**

**Thermo-economic optimization:-** Introduction ; optimization of heat exchanger networks ; analytical and numerical optimization techniques ;design optimization for the co-generation system- a case study ; thermo-economic optimization of complex systems

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING**


1. Thermal Design & Optimization - Bejan, A., et al., John Wiley, 1996
2. Analysis & Design of Thermal Systems - Hodge, B.K., 2ndedition, Prentice Hall, 1990.
3. Design of Thermal Systems - Boehm, R.F., John Wiley, 1987
4. Design of Thermal Systems - Stoecker, W.F., McGraw-Hill

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| 11 | 16MTP424 | Group-3 | Experimental Methods in Thermal Power Engineering |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Basics of Measurements**: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction

**Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

**Module 2**

**Thermometry:** Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer.

**Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

**Module 3**

**Flow Measurement:** Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods**.**

**Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.Other measurements: Basics in measurement of torque, strain.

**Module 4**

**Analysis of experimental data:** Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.

**Sensing Devices :**Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

**Module 5**

**Air-Pollution:** Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement.

**Advanced topics**: Issues in measuring thermo physical properties of micro and Nano fluids. Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

**READING**


1.Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper, 2004, PHI.
2. Process Control: Principles and Applications; Surekha Bhanot, Oxford University press, Fourth Impression, 2010.
3. Instrumentation, Measurement and Analysis; BC Nakra, and KK Chaudhry; 2 ed, 2004, Tata McGraw-Hill
4.Transducers and Instrumentation; DVS Murthy, 2003, PHI
5.Instrumentation Devices and Systems; CS Rangan, GR Sarma, and VSV Mani; 2 ed, Tata McGraw-Hill
6.Measurement Systems Application and Design; Doeblin and Ernest; 5 ed, 2004, Tata McGraw-Hill.
7.Measurement Systems – Applications & design; Doeblin E.O. 4th ed. Mc. Graw Hill
8.Principles of Industrial Instrumentation, Patranabis D. TMH – 1997
9.Mechanical & Industrial Measurements, Jain R.K, Khanna Publishers – 1986
10.Process Instruments and control Hand book, Considine D.M, 4th ed, Mc.Graw Hill
11.Instrument Technology – Vol.1m, Jones E.B., Butterworths – 1981
12.Control Systems Engineering, Nagrath&M.Gopal, Wiley Eastern
13.Automatic Control Systems, B.C.Kuo, John Wiley, 2009
14.Modern Control Engineering, Katsuhiko Ogata, Prentice Hall

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| 12 | 16MTP21 | Group-3 | ADVANCED HEAT TRANSFER |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction and one-dimensional heat transfer: T**he differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins of uniform cross section and non uniform cross sections, Thermal resistance networks and applications.
**Numerical heat Transfer**: Numerical techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, Controlling Numerical Errors, problems.

**Module 2. Thermal radiation:** basic concepts and laws of thermal radiation, the shape factor, Eradiant heat exchange in enclosures ,black and Grey surfaces ,radiation shields and Radiation Effect on temperature measurements. Radiation properties of participating Medium, Emissivity and absorbivity of Gases and Gas Mixtures, Heat transfer from the Human Body problems.

**Module 3. Analysis of Convection Heat Transfer:** Boundary layer fundamentals evaluation of convection heat transfer coefficient, Analytical solution for laminar boundary layer flow over a flat plate ,Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynolds Analogy for Turbulent Flow Over Plane Surfaces, Mixed Boundary Layer, Special Boundary Conditions and High-Speed Flow

**Module 4. Natural convection:** Introduction, Similarity Parameters for Natural Convection, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Finned Surfaces
**Heat transfer by forced convection:** Introduction, Analysis of Laminar Forced Convection in a Long Tube, Correlations for Laminar Forced Convection, Analogy Between Heat and Momentum Transfer in Turbulent Flow, Empirical Correlations for Turbulent Forced Convection, Heat Transfer Enhancement and Electronic-Device Cooling, Flow Over Bluff Bodies , Packed Beds, Free Jets

**Module 5. Heat exchangers:** Basic concepts**,** types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multi-pass and Cross-Flow Heat Exchangers, Use of a Correction Factor , Selection of Heat Exchangers such as Heat Transfer Rate ,Cost ,Pumping Power, Size and Weight ,Type, Materials, Other Considerations, Compact Heat Exchangers. Heat Exchangers for multi phase flow.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


1. **Heat Transfer – A Basic Approach -** Ozisik M.N., McGraw-Hill Publications, 1st edition.
2. **Heat Transfer -** Holmon J.P., McGraw-Hill Publications, 6th Edition.
3. **Principles of Heat Transfer -** Frank Kreith,Thomson Publications, 7th Edition.
4. **Heat Transfer-** A practical Aproach ,Yunus A CengelMcGraw-Hill Publications 2nd edition

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| 13 | 16MCS421 | Group-3 | WIND ENERGY ENGINEERING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Introduction:** Historical uses of wind, history of wind electric generation, horizontal axis, wind turbine, Innovative wind turbines.

**Wind Characteristics:** Metrology of wind, world distribution of wind, Atmospheric stability, Wind speed, variation with height, wind speed statistics, Weibull statistics, determining Weibull parameters, Rayleigh & normal distributions.

**MODULE 2**

**Wind Measurements:** Eolian features, biological indicators, rotational anemometers, other anemometers, wind direction, wind measurements with balloons.

**Wind Turbine Power, Energy & Torque:** power output from an ideal turbine, aerodynamics, power output from practical turbines, transmission & generator efficiencies, energy production & capacity factor, torque at constant speeds, turbine shaft power and torque at variable speeds.

**MODULE 3**

**Wind Turbine Connected To Electrical Network:** Methods of generating synchronous power, AC circuits, the synchronous generator, the induction machine, power calculation, motor starting, features of electrical network.

**Wind Turbines With a Synchronous Electrical Generators:**Asynchronous systems, DC shunt generator life battery head permanent magnet generator, AC generators, self excitation of induction generator, single phase operation of induction generator, field mounted generator, Rosel generator.

**MODULE 4**

**Asynchronous Head:** Piston water pumps, Centrifugal pumps, paddle wheel heaters, batteries, hydrogen economy & electrolysis cells.

**MODULE 5**

**Economics Of Wind Systems:** Capital costs, economic concepts, revenue requirements, value of wind generated electricity, hidden costs & non economic factors in industrialized nations, economic & non economic factors in developing nations, break even points, tariff calculations.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**


1. Gary-L. Johnson: “Wind Energy Systems” - McGraw-Hill Book Company, 1982.
2. V.Daniel Hunt:“Wind Power”- Van Nostrand Rein-ford Company, 1985.


**REFERENCE BOOKS:**


1. D.F. Warne:“Wind Power Equipment” - E& FN Spon, 1983.
2. L. Jarass: “ Wind Energy”- Springer London, Limited. Course Outcome:

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| 14 | 16MTP23 | Group-3 | ADVANCED POWER PLANT CYCLES |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**1.Analysis of Steam cycles:** Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermalefficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, carnotization of Rankine cycle, optimum degree of regeneration, Super critical pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a steam power plant, Cogeneration of Power and Process Heat, Numerical Problems.

**Combined cycle power generation:** Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid in vapor power cycle, Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine- steam turbine power plant, MHD-steam power plant, Thermionic- Steam power plant.

**2.Fuels and combustion :** 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.

**3.Steam Generators:** Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, superheaters, reheaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, de-aeration, evaporation, internal treatment, boiler blow down, steam purity, Numerical problems.

**Condenser, feed water and circulating water systems:** Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems.

**4.Nuclear Power Plants:** Chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water and Fusion Power reactors.

**5.Hydro Electric Power Plant:** Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage.

**Power plant Economics:** Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipments

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


1. **Power Plant Engineering** - P.K. Nag, Tata McGraw-Hill Publications. 2nd edition
2. **Power Plant Engineering** - M.M. EI-Wakil, McGraw- Hill Publications. 1st edition
3. **Power plant engineering –**R. K. Rajput, Laxmi Publications 3rd edition

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| 01 | 16MST14 | Group-4 | NANO SCIENCE AND NANOMATERIALS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**1.Introduction To Nanoscience And Nanotehnology :** History, background scope and interdisciplinary nature of nanoscience and nanotechnology, scientific revolutions, nano sized effects surface to volume ratio, atomic structure, molecules and phases, energy at the nanoscale molecular and atomic size, quantum effects ,types of nanotechnology and nano machines.

Classification Of Nanostructures: Zero dimensional, one-dimensional and two dimensional nanostructure materials-clusters of metals, semiconductors, ceramics and nano composites, size dependent phenomena, quantum dots nano wires ,tubes ,nano sheets ,nano and mespores, top down and bottom ups approach, misnomers and misconception of nano techonology, importance of nanoscale materialsand their devices.

**2. Properties Of Nanomaterials:** Mechanical properties-Thermo physical properties - Electrical properties Electric properties – Electro chemical properties Magnetic properties - optical properties-Catalytic property – properties of gas pe rmeation and separation membranes.

**Nanostructure Design:** Functionality of nanostructures and their characteristics evaluation, size effect in semiconductor nanoparticles – particle size, shape density – Melting point, surfa ce tension, wettability – specific surface area and pore – Assembly of nanoparticles and fictionalization – nanoparticles arranged structure s as nanipores and nanocomposites – Structure contr ol of nanoparticle collectives by sintering and bounding – Self – assembly. Nanoparti cle dispersion and aggression behaviour – Single na noparticle motion in fluid – Brownian diffusion – Adsorption properties – intera ctions between particles – Aggregation and dispersi on, characterization and control – Rheology of slurry – Simlation of colloidal dispers ion system

**3. 3. Melting Point And Phase Transition Processes :** quantum-size-effect (QSE) Size-induced metal-insulator-transition (SIMIT) nano-scale magnets, transparent magnetic materials and ultrahigh-density magnetic recording materials – chemical physical of atomic and molecular clusters. Surface energy – chemical poten tial as a function of surface curvature – Electrostatic stabilization – surface charge density-electric potential at the proximity of solid surface-van der Waals attraction potential. Photochemistry, Photoconductivity, Electrochemistry of nanomaterials – Diffusion in Na nomaterials , Nanoscale Heat transfer, Catalysis by Gold Nanoparticles, Transport in semiconductor Nanostructures, Transition Metal Atoms on Nanocarbon Surfaces, Nano deposition of soft materials, Nanocatalysis.

**Surface Modification Of Nanoparticles:** Surface modification of inorganic nanoparticles by organic functional groups Instantaneous nano foaming method for fabrication of closed –poro sity silica particle- Development of photo catalyst inserted into surface of porous alumina silicate- Fabrication technique of organic nano crystals and their optical properties and matetialization, Dispersion control of nanoparticles in solvents – Development of new cosm etics based on nanoparticles – Development of funct ional skincare cosmetics usingbiodegradable PLGA nano spheres.

**4. Application Of Quantum Dots For Bio-Medical Engineering:** Bio- imaging with quantum dots – Pinpoint drug and gene delivery-delivery to the brain – Development of the thermo r esponsive magnetic nanoparticle and its deployment in the biotechnology field, Addressing of nanoparticles by using DNA molecules, Nanoparticle formation of DNA (globule transformation) – Development and multi-functionalization of high – functional separ ation membranes – Design of nanoparticles for oral delivery of peptide drugs.

**5. Smart Materials And Systems :** Thermoresponsive materials, piezoelectric materials, electrostrictive and magnetostrictive materials, ferrofluids, ER and MR fluids, biomimetic materials, smart gel, shape memory alloys and polymers, actuation methods, measurements.

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**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. Edward L. Wolf. "Nanophysics and Nanotechnology" – An Introduction to Modern Concepts in Nanoscience " Second Edition, John Wiley & Sons, 2006.
2. K.W. Kolasinski, "Surface Science Foundation of Cat alysis and Nanoscience ", – Wiley, 2002
3. G.A. Ozin and A.C. Arsenault, "Nanochemistry: A che mical approach to Nanomaterials" , 2005.
4. Nanostructues and Nanomaterials Synthesis, Properties and applications, G.Cao Imperial Collage Press 2004.

**REFERENCEBOOKS :**

1. Valdimir P, Torchilin (2006) Nanoparticulates as Drug Carriers imperial college press.
2. M Reza Mozafari (2007) Nanomaterials and Nanosystems for Bio-Medical Applications springer.
3. Nanotechnology – Basicscience and emerging technolo gies Chapman and Hall/CRC(2002).
4. Nanomaterials and Nanotechnologies and design on introduction for engineers and architects, Micheal F. Ashby, P.J. Ferreria, D.L. Sehodek.

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| 02 | 16 MST151 | Group-4 | ADVANCED MATERIALS AND PROCESSING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Classification and Characteristics:** Metals, Non ferrous Metals and Ferrous Metals, classification of Ferrous Metals and Non Ferrous Metals, Types of Ceramics, Polymers and composites and classification of composites.

**General Properties and Structure:** Atoms, molecules bonds in solids, Crystalline - Defects in Metallic structure, Dislocations and plastic deformation - Strengthening mechanism - grain size, dislocation - Cold work, precipitation hardening, dispersion hardening - phase reactions, fatigue and Creep behaviour.

**Ferrous Alloys:** iron carbon equilibrium diagrams - Steels and cast irons - properties, structure, composition and applications transformation hardening in steels - TIT diagrams - Heat treatment processes - Effect of alloying elements - High alloy steels, Stainless steel types, tool Steels, Manganese steels, heat resistant steels, HSLA, Managing steels.

**Non Ferrous Alloys:** Alloys of copper, Aluminium, nickel, magnesium, titanium, lead, tin, Zinc - composition, heat treatment, structure, properties and application**.**

**Module 3**

**Polymers and Polymerizations:** Structure and properties of thermoplastics and thermo sets – Engineering Applications - property modifications - Mechanical and thermal behaviour – processing methods

**Ceramics :** Nature and structure of Ceramics - Refractory Abrasives glasses - glass ceramics - Advanced ceramics processing methods.

**Module 4**

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

**Module 5**

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

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**


1. Engineering Metallurgy - Raymond and Higgens - ELBS/EA
2. Introduction to Material Science and Engineering James.F.Shackleford - Mc Millan, NY - 7th edition.


**REFERENCE BOOKS:**


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

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| 03 | 16MST152 | Group-4 | ADVANCED FOUNDRY TECHNOLOGY |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module-1 Solidification of Casting:** Concept of solidification of metals. Homogenous and heterogeneous nucleation. Growth mechanism. Solidification of pure metals and alloys. Mechanism of columnar and dendritic growth. Coring or Segregation. Solidification time and Chvorinov's rule. Concept of progressive and directional solidifications.

**Principles of Gating and Risering:** Purpose of the gating system. Components of the gating System and its functions. Design of the gating System. Different types of gates. Gating ratio and its functions. Definition and functions of the riser. Types of risers and their application. Design of the riser - its shape. Size and location. Use of insulating material and exothermic compounds in risers.

**Module-2 Design of Casting and Quality Control:**: Factors to be considered in casting design. Design consideration in pattern making, moulding techniques and core making and assembly. Cooling stresses and hot spots in casting and modification in casting geometry to overcome them. Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. Quality control activities in a foundry. Salvaging methods of defective casting.

**Furnace Technology:** Study of various furnaces used in foundry, construction and operation of crucible and hearth furnaces. Resistance, Arc and Induction furnaces-their construction. Operation and application. Heat treatment furnaces and drying ovens used in foundry.

**Module-3 Gray Cast - Iron Foundry Practice Malleable Cast Iron:** Chemical Composition and structure of gray cast iron. Moulding, gating and risering techniques. Melting of gray cast iron in Cupola and induction furnace. Inoculation of gray cast iron. Application of gray cast iron castings. Chemical composition and structure of White-heart and black-heart malleable cast iron. Melting malleabilisation heat treatment and application of malleable cast iron.

**Module-4 Aluminium Foundry Practice:** Composition, properties and application of common aluminum alloy casting. Melting and casting of AI-alloys. Gating and risering of AI-alloy casting.

**Copper Alloy Foundry Practice:** General characteristics of common cast copper alloys. Melting and casting of copper alloys. Gating and risering of cu-alloy castings

**Module-5 Foundry Mechanization and Modernization:** Introduction to modernization. Mechanization of foundry and its advantages. Mechanization of sand plant, moulding and core making mechanization in melting, pouring and shakeout units. Material handling equipments and conveyor systems. Brief sketches and description of layouts of job. Captive and mechanized foundries.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. A Test Book of FoundryTechnology - Lal, M. Khanna, P.O - DhanpatRai & Sons Publication.

REFERENCE BOOKS:

1. Principle of Metal Casting - Heine, et. al - Tata-McGraw-HiII Publication - 2003.
2. Foundry Technology - Beelely, P.R. – Butterworth.

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| 04 | 16MST21 | Group-4 | COMPOSITE MATERIALS TECHNOLOGY |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module-1** Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.
Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of
arbitrary orientation, Numerical problems.

**Module-2** Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems.
Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems.

**Module-3** Macro Mechanical Analysis of Laminate: Introduction, code, Kirchoff hypothesis, CLT, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.
Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

**Module-4** Metal Matrix Composites: Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection,Applications.

**Module-5** Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment- future potential of composites.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Composite Materials handbook, Mein Schwartz Mc Graw Hill Book Company, 1984.
2. Mechanics of composite materials, Autar K. Kaw CRC Press New York.

**Reference Books:**

1. Mechanics of Composite Materials, Rober M. Joness Mc-Graw Hill Kogakusha Ltd.
2. Stress analysis of fiber Reinforced Composite Materials, Michael W, Hyer Mc-Graw Hill International.
3. Composite Material Science and Engineering, Krishan K. Chawla Springer.
4. Fibre Reinforced Composites, P.C. Mallik Marcel Decker.

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| 05 | 16MST41 | Group-4 | PLASTIC PROCESSING |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module 1. Plastic Processing:** Basic principle of processing, shape and size, processing parameters, their effect and behavior, Rheology of ideal fluids, and real polymers, Effects of melt behavior on processing and product performance.

**Injection Moulding:** Principles, process variables, moulding cycle, machinery used, parts and function, specification, construction and maintenance of injection moulding machine, start up and shut down procedure, cylinder, nozzles, interaction of moulding variables, press capacity, projected area, shot weight, concepts and their relationship to processing, trouble shooting in injection moulding, microprocessors controlled injection moulding machines.

**Module 2. Extrusion:** Basic principles of extruders, and extrusion process, different types of extrudes i.e. barrel, screw, drive mechanics, head, constructional features of dies, sizing and haul-off equipment for extruders of mono filaments and tubes, blown film lines, wire and cable covering system, pipe profile extrusion, co-extrusion, process variables in extrusion like heating, temperature control, dies well, and melt fracture, spacing and orientation, treating, printing and sealing, quality of extruder products, fault, causes and remedy.

**Compression and Transfer Moulding:** Techniques, various types of compression moulds, machinery used, and common moulding faults and remedies. Transfer moulding, its advantage over compression moulding, equipment used, press capacity, integral mold, and auxiliary mould, moulding cycle, ram pressure, clamping pressure, faults and remedies.

**Module 3. Blow Moulding:** Blow moulding process, processing parameter, materials used, hand operated and automatic blow moulding machine, extrusion blow moulding, moulding cycle, faults and remedies**.**

**Thermo Forming:** Basic principles, types of thermoforming, thermoforming moulds, processing parameters, faults and remedies.

Rotational Moulding: Basic principle, charge size, wall thickness, temperature control, fault causes and remedies.

**Module 4. Calendaring**: Basic principle, process variable, end product properties and applications, secondary processing techniques like powder coating, casting, machining, and joining of plastics, metalizing, and printing.

**Module 5. Processing of Engineering Plastics:** precautions, and start up procedure, preheating, shutdown procedure, quality control, and waste management. Ram Extrusion of PTFE, Processing of reinforced plastics, like filament winding, Hand-lay-up, spray moulding, SMC, DMC, Centrifugal casting, pultrusion, resin transfer moulding.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**1.** Plastic Processing Data Hand Book – Dominic V Rosat o P.E.
**2.** Modern Plastics Hand Book – Charles A Harper.

**REFERENCE BOOKS:**

**1.** Injection Mould Design, Pye R.G. W. - New York-John Wiley & Sons 12th Ed.1989.
**2.** Injection Moulding Theory & Practice, Rubin. J. Irvin, New York John Wiley & Sons.
**3.** Blow Moulding Hand Book, Rosato, New York-Oxford University-Hanser Publishers.
**4.** Principles of Rotational Moulding Process, Bruins.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 06 | 16MST13 | Group-4 | MATERIALS FOR CRYOGENIC AND HIGH TEMPRATURE APPLICATIONS |
|---|---|---|---|

| Exam Hours:03 | Exam Marks:100 |
|---|---|

**Module-1 Introduction: Historical Background –** Introduction to Cryogenic p ropellants – Liquid hydrogen, Liquid helium, Liquid nitrogen and Liquid oxygen and their properties.
Production of low Temperature: Theory behind the production of low temperature – E xpansion engine heat exchangers – Cascade process Joule Thompson Effect – Magnetic effect – O rtho and Para H2 – Helium4 and Helium3**. 12 Hours**

**Module-2 Efficiency of Cryogenic Systems:** Types of losses and efficiency cycles – Specific am ount of cooling – The fraction liquefied – Cooling coefficient of performance – Thermodynamic efficiency – The energy balance Methods.
Cycles Of Cryogenic Plant: Classification of cryogenic cycles – The structure of cycle – Throttle expansion cycles – Expander cyc les –
Thermodynamic analysis – Numerical problems**. 13 Hours**

**Module-3 Cryogenic Fluid Storage And Transfer Systems:** Basic storage vessels, insulations, un insulated and porous insulated lines, vacuum insulated lines, cryogenic valves, cool down process.
Measurement Systems For Low Temperatures : Introduction, Temperature scales and fixed points, Metallic resistance thermometers, thermo couples, constant volume gas thermometers, magnetic thermometers, vapour pressure thermometers. 12Hours

**Module-4 Vacuum Technology :** Importance flowregimes in vacuum system, components of vacuum system, mechanical vacuum pumps, diffusion pumps, vacuum gaugs and valves **6 Hours**

**Module-5 Cryogenic In Aerospace Applications:** Cryogenic liquids in missile launching and space simulation – storage of cryogenic liquids-Effect of cryogenic liquids on properties of Aerospace materials – Cryogenic loading problems – Zero g ravity problems associated with cryogenic propellants – Phenomenon of tank collapse – Elimination of Geysering effect in missiles **7 Hours**

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**


**1. Barron.R.F. Cryogenic Systems, Oxford University, 1985.**
**2. DURHAm, T.F, MCCLINTOCK, R.M. and REED, R.P.(1962). Cryogenic Materials, Washington,D.C**


**REFERENCE BOOKS:**


**1. Haseldom .G. Cryogenic Fundamentals, Academic Press, 1971.**
**2. Parner S.F. Propellant Chemistry, Reinhold publishing Corpn., NewYork 1985.**
**3. Wigley D.A.(1971) Mechanical Properties of Materials at Low Temperatures. Plenum Press, New York.**

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 07 | 16MST23 | Group-4 | TESTING OF MATERIALS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Testing machines and sensors**: types of Universal Testing machines and principles of operations, Machine stiffness, load and strain measurement. Calibration and verification of UTM.
**Friction, wear and surface testing:** Testing of sliding contact, damage, abrasive wear, adhesive wear, erosive wear. Testing and determination of surface characteristics of solid materials.(Surface roughness measurements)

**Module 2. Importance of calibration of Testing Instruments:** Calibration methods and standards .Tests / experiments based on methods with active reference to various codes and standard for each test.
**Failure Analysis:** Principles and Approaches of Failure analysis, objectives, scope, planning, preparation. Failure Analysis procedures. Examination of damages and materials evaluation. Tools and Techniques in FA – An overview. Appearances of fracture in common conditions like unit axial loads, tensional and shear loads, fatigue and creep loading.

**Module 3. Microscopy:** Optical microscope, scanning electron microscope. Preparation of Specimens for microscopic study**.**
**Speed & Control of Testing** Background, Developments in testing Machine Technology, Effects of testing rates on properties, Results before servo control, Results from servo controlled machines.

**Module 4. Strain Rate Testing** Aim of Recommendations, Abbreviations and Symbols, Test Machine Requirements, Specimens Measurements, Data Processing, General Definitions Strength Hardening Constitutive Relations to Model Material Strain Rate Dependency.

**Module 5. Lubrication & Determination of characteristics of lubricants:** Introduction, Types of lubricants, characteristics of lubricants. Methods of lubrication, four ball testing.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**1.** Testing of Metallic Materials – A.V.K. Suryanarayan , Prentice Hall of India.

**REFERENCE BOOKS:**

**1.** ASM Vol Testing of materials
**2.** Inspection of Materials, Vol. II – Destructive Meth ods, R.C. Andersen, ASM 1988.
**3.** Workability Testing Techniques, G.E. Dieter, ASM 1984.
**4.** Relevant codes and standards.

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| 08 | 16MCS254 | Group-4 | NANO TECHNOLOGY |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1 Introduction :** Overview of Nanosience and Engineering, Classification of nanostructures, Nanoscale Architecture, Scaling and miniaturization laws, Why use miniaturization technology- Effect of the nanometer length scale, Fabrication processes- Top down and Bottom up processes, Characterization techniques

**Physics Of Nanoscience:** Electronic properties of Atoms & Solids, The isolated atom – Bonding between atoms – I, CAOVan der waals forces – Dispersion interaction – Orientational interactio n – Induction interaction. Stating Schrodinger's w a ve equation and its importance – physical significance of wave function – Eigen values and Ei gen functions. The Free electron (Particle) model and energy bands – particle in 1-D potential well of infinite height (discussion on energy values, wave functions – normalization and probability d ensities ). Particle in 1-D potential well of finite height – Concept of tunneling. – Heisenberg' s uncertainty principle – Derivations of Density o f states for 3D, 2D, 1D and 0D and graphical representations.

**Module 2 Effects Of Nanometre Length Scale:** Changes to the system total energy. Changes to the system structure. How nanoscale dimensions affect properties – structural, thermal, chemical, mechani cal, magnetic, optical and electrical. **Semiconductor Physics** – To Understand Inorganic Semiconductor Nanostructures:What is a semiconductor ? Doping, The concept of effective mass, Carrier transport, mobility and electrical conductivity, Optical property of semiconductors, Excitions, The pn junction, Phonons, Types of semiconductors, Quantum Confinement In Semiconductor Nanostructures,Quantum confinement in one dimension : quantum well.Quantum confinement in two dimension : quantum wires.Quantum confinement in three dimension : quantum dots, Superlattices, Band offsets.

**Module 3 Chemistry Of Nanoscinece Concept And Materials:** chemistry of Carbon Fullerenes,structure and synthesis, chemical reactivity-chemistry of higher fullerenes- applications Nanotubes, Carbon forms structured by energetic species-amorphous nanotubes and crystalline forms, carbon-an ideal model system to study structuring by energetic species, structuring of amorphous carbon forms, structuring of ordered sp2 forms, structuring carbon nanotubes : Electric arc (arc evaporation) technique, laser ablation, catalytic decomposition of hydrocarbons purification. Structure and properties of carbon nanotubes. Inorganic nanotubes, structure, synthesis and properties. Electron transport in nanotubes. Ballistic, Spintronics, Coulomb blockade and Nanowire. Organic semiconductors, Organic light emitting diodes.

**Module 4 Self- Organization:** Phase behavior of nanoparticle suspensions, hard sphere behavior, soft repulsions, and weakly attractive suspensions, Catalysis, Nanocrystalline Zeollites –Hydrothermal synthesis of nanocrystalline zeollites application in environmental catalysis, selective partial oxidation reactions of hydrocarbons and photo catalytic decomposition of organic contaminations using nanocrystalline zeollites.

**Characterization Basic Of Scatering Physics Related To Characterization:** X rays and their interaction with matter, Electron and their interaction with matter, Phonon scattering, Plasomon scattering, Single-electron excitation, Direct radiation losses, Neutrons and their interaction with matter, Ions and their interaction with matter, Elastic scattering and diffraction, Technology of Characterization, Profilometry, Optical microscope, SEM, TEM, FIB, STM, AFM, Surface Raman Scattering, wettability (contact angle) measurement small angle X-ray diffraction and electron diffraction

**Module 5 Fabrications and Characterizations of Nano Structures:** Milling, Silicon VLSI fabrication processes-Doping, Oxidation / Deposition, Etching, Lithographic, processes – Photo, c- beam, F ocused ion beam, x-rays Soft lithography, Machining – Micromachining, micromachining, LIGA. (MEMS processes), Applications, Nano and Micro machines (NEMS AND MEMS), Liquid phase methods molecular and biological computing, Colloidal methods, Sol-gel methods, Electrodeposition, Self-assembly and self-organization, processes

**Nanotribology Composition And Structure Of Surfaces Natural Condition :** oxide and hydrocarbon films surface segregation and reaction with environments, thermodynamics structure of surfaces, atomistic simulations methods to study composition and structure of surfaces, composition –Auger electron spectroscop y , X-ray photoelectron spectroscopy, structure, LEED,STM/AFM XRD,HREM. Chemical interactions on surfaces, adsorption and deposition on surfaces (physisorption and chemisorption), Langmuir adsorption isothenn, desorption from surfaces : Electronic properties and surface reactions relevant to tribology, density functional studies analysis of structure sensitivity lubricant degradation. Nanomechanical properties : Determination of surface mechanical properties (AFM/nanoindentation),

simple friction theories effects of surface compostion and structure on friction, environmental and temperature effects, relationship with surface chemistry, mixed and boundary lubrication, failure mechanisms.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS :**

1.Ed. William A Goddard III, Donald W Brenner, Sergey Edwart Lyschevski and Gerald J. Iafrate: "Handbook of Nanoscience Engineering and Technology"- CRC Press, New York (2003)
2.Ueno T., Ito T and Nonogaki: "Microlithography fundamentals in Semiconductor de vices and Fabrication Technology"- S Marcel Dekker(1988).

**REFERENCE BOOKS :**

1.William moreau:"Semiconductor lithography Principles, Practies and materials" -plenum press (1988)
2.ULSI, ED. By Matsui S., Ochiai Y and Suzuki K:"Sub-Half micron Lithography" - Cambridge University Press (1999)
3.A Borderland Between STM, EB, IB and X-ray Lithographies, Ed. By Gentili M., GiovannellaC., and Selci S.,NATO: "Nanolithography"
4.Kluwer: "Asi Series E Applied Sciences"- vol.264, Academic Publishers (1994).

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 09 | 16MCS423 | Group-4 | ANALYSIS AND DESIGN OF COMPOSITES |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

**Module 2**

**Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems. Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems.

**Module 3**

**Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.

**Manufacturing:** Lay up and curing - open and closed mould processing, Hand lay, Up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling, Quality assurance, Introduction, material qualification, Types of defects, NDT methods.

**Module 4**

**Application Developments:** Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.

**Module 5**

**Metal Matrix Composites:** Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**


1. Mein Schwartz:**"Composite Materials handbook" -** Mc Graw Hill Book Company, 1984.
2. Autar K. Kaw CRC**: "Mechanics of composite materials" -** Press New York.


**REFERENCE BOOKS:**


1. Rober M. Joness:**"Mechanics of Composite Materials" -** Mc-Graw Hill Kogakusha Ltd.
2. Michael W, Hyer:**"Stress Analysis Of Fiber Reinforced Composite Mate rials"-** Mc-Graw Hill International.
3. Krishan K. Chawla Springer.:**"Composite Material Science and Engineering"**
4. P.C. Mallik Marcel Decker:**"Fibre Reinforced Composites"**

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 10 | 16 MST153 | Group-4 | NON DESTRUCTIVE TESTING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Introduction to ND Testing:** selection of ND methods, visual inspection, leak testing, Liquid penetration inspection, its advantages and limitation.

**Magnetic Particle Inspection:** Methods of generating magnetic field, types of magnetic particles and suspension liquids steps in inspection – application and limitations .

**Module 2**

**Eddy Current Inspection:** principles, operation variables, procedure, inspection coils, and detectable discounts by the method.

**Microwave Inspection:** Microwave holography, applications and limitations.

**Ultrasonic Inspection:** Basic equipment characteristics of ultrasonic waves, variables inspection, inspection methods pulse echo A,B,C scans transmission, resonance techniques, transducer elements couplets, search units, contact types and immersion types inspection standards-standard reference blocks.

**Module 3**

**Radiography Inspection:** principles, radiation source X-rays and gamma rays, X-ray-tube, radio graphic films, neutron radiography, Thermal inspection principles, equipment inspection methods applications.

**Module 4**

**Optical Holography:** Basics of Holography, recording and reconstruction - Acoustical Holography: systems and techniques applications. Indian standards for NDT.

**Module 5**

**Visual Inspection and Thermographic methods :** Acoustic emission, Total acoustic emission, felicity ratio, Generation of Acoustic Emission.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. The Testing Instruction of Engineering Materials - Davis H.E Troxel G.E wiskovil C.T - McGraw hill.

**REFERENCE BOOKS:**

1. Non Destructive Testing - Mc Gonnagle JJ – Garden a nd reach New York.
2. Non Destructive Evolution and Quality Control - volume 17 of metals hand book 9 edition Asia internal 1989.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 11 | 16MST422 | Group-4 | BIO MATERIAL AND TECHNOLOGY |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction**: Definition of Bio materials, Classification of Bio materials, Comparison of properties of some common bio materials, effects of physiological fluid on properties of bio materials, surface properties, physical and Mechanical properties of Bio materials.

**Metallic Implants Materials** : Stainless Steel, Co-based alloys, Ti and Ti based alloys, Important of stress corrosion cracking, Host tissue reaction with Bio metal, corrosion behaviour, hard tissue replacement implant, orthopedic implant, dental implants, Percutaneous and skin implants, Vascular implants, Heart valve implant.

**Module 2. Polymeric Implant Materials**: Polyolefins, polyamides, acrylic polymers, fluoro carnon polymers, Silicon rubber acetals. Visco elastic behaviour, creep recovery, stress relaxation, strain rate sensitivity, importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives, aging and environmental stress cracking, physiochemical characteristics of bio polymers, bio degradable polymers for medical purpose and their biological applications.

**Ceramic Implant Materials:** Definitions of Bio ceramics, common type of Bio ceramics, Aluminium oxides, Glass ceramics, Carbons. Bioresorbable and Bioactive ceramics, Importance of wear resistance and low fracture toughness. Host Tissue reactions, Importance of Interfacial tissue reaction**.**

**Module 3. Composite Implant Materials**: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement, polymers filled with osteogenic fillers (e.g. hydrosyapatite). Host tissue reactions.

**Bio Compatibility And Toxicological Screening Of Bio Materials :** Definition of bio compatibility, blood compatibility and tissue compatibility, toxicity tests, acute and chronic toxicity ( in situ implantation, tissue culture, haemolysis, thermombogenic, potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenesity and special tests.

**Module 4. Testing Of Bio Materials Implants**: In vitro testing (Mechanical testing): tensile, compression, wears, fatigue, corrosion studies and fracture toughness. In vivo testing (animals): biological performance of implants. Exo-vivo testing, standards of implant materials.

**Module 5. Sterilisation Techniques**: ETO, gamma radiation, autoclaving, Effects of Sterilisation on material properties**.**

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**1. 1.** Jonathan Black, Biological performance of materials, MarceDecker, 1981.

**2.** C.P. Sharma & M. Szyehen, Blood Compatible Materials and Devices, Technonic Publishing Co Ltd., 1991.

**REFERENCE BOOKS :**

**1.** Piskin and A. S. Hofmann, Polymetric Biomaterials Mantinus Nijhoff publication bordrechnt 1986.

**2.** J.B. Park, Biomaterials, Science and engineering Plenum Press 1984

**3.** Sjuata V. Bhat Biomaterials Nonosa Publishing House – 2002

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| 12 | 16MST423 | Group-4 | MECHANICAL BEHAVIOUR OF MATERIALS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Strength of materials**- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials Mohr's circle, yielding theories.

**Theory of plasticity:** Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening

**Ductile and Brittle Fracture:** Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith's theory, LEFM– COD and J integral –determination of KIC, COD and J integral.

**Characteristics of fatigue failure:** Initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of f atigue data, mechanics of fatigue crack propagation, corrosion fatigue.

**Introduction to creep**:- creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Hafred parameter

**Stages of failure analysis**, classification and identification of various types of fracture.Overview of fracture mechanics, characteristics of ductile and brittle fracture.General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

**Types of wear**, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures.

**Causes of failure in forging**; failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS**

**1.** Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988.

**2.** Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.

**3.** Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984

**REFERENCES BOOKS**

**1.** ASM Metals Handbook "Failure Analysis and Preventio n", ASM Metals Park. Ohio,Vol. 10, 10th Edition, 199 5.

**2.** Colangelo.V.J. and Heiser.F.A., "Analysis of Metall urgical Failures", John Wiley and Sons Inc. New Yor k, USA, 1974.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 13 | 16MST251 | Group-4 | SURFACE TREATMENT AND FINISHING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Fundamentals of Electro plating**, galvanizing, Hot dip metal coating, thin coating, thin coating, chromium plating, Nickel plating.
**Vacuum coating**, FVD & CVD metal spraying - Methods, surface preparation, mechanical.

**Module 2. Properties of sprayed metals**, Various types and plasma coating.
**Plastic coating of metal** - PVC coating Spherodising process details, phosphate coating - mechanism of formation.

**Module 3. Testing of surface coating**- Various methods used.
**Heat treatment methods**, Annealing, Normalizing, Tempering, Case hardening methods, flame hardening sub zero treatment.

**Module 4. Heat treatment methods for gears, spindles, cutting tools.**

**Module 5. Advanced coating technologies:** Hard facing, electro deposition technique, nanocoatings, **coating** characterization.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**

**1.** Surface preparations & finishes for Metals - James A Murphy - McGraw Hill.

**REFERENCE BOOKS:**

**1.** Principles of metal surface treatment and protection - Pergamon Press Gabe, David Russell - Description, Oxford ; New York - 2d ed., 1978.
**2.** Handbook of metal treatment and testing - John wiley & sons.
**3.** Heat Treatment of Metals – Zakrov - MlR Publication s.
**4.** Metals Hand Book – ASM.

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| 14 | 16 MST154 | Group-4 | SELECTIONS OF MATERIALS IN ENGINEERING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1Introduction to Selection of Mechanical Properties:** Types of materials Static strength, Toughness, Stiffness, Fatigue Creep, Fatigue & Thermal Properties.

**Module 2Selection for corrosion resistance** The nature of the corrosion process , selection of materials for resistance to atmospheric corrosion , selection of materials for resistance to oxidation at elevated temperatures , selection of materials for resistance to corrosion in the soil , selection of materials for resistance to corrosion in water , selection of materials for chemical plant , degradation of polymeric materials.

**Selection of materials for resistance to wear:** The mechanisms of wear, The effect of environment on wear Surface treatment to reduce wear , Erosive wear , Selection of materials for resistance to erosive wear.

**Module 3**

**The relationship between materials selection and materials processing:** The purpose of materials processing, the background to process selection. The casting of metals and alloys, wrought products, the manufacture of plastics. Fabrication from powder, Fastening and joining.

**Module 44. Materials for Aerospace Application:** Principal characteristics of aircraft structures, Property requirements of aircraft structures, Requirements for high-speed flight, Candidate materials for aircraft structures.

**Materials for ship structures & automotive application:** The ship girder, Factors influencing materials selection for ship hulls, Materials of construction

**Module 5**

**Materials for engines and power generation:** Internal combustion, External combustion.

**Materials for bearings &High Temperature Application:** Rolling bearings, Plain bearings.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. F A A Crane and J A Charles.

**REFERENCE BOOKS:**

1. Engineering Materials by O.P.Khanna. Applied Materials W.D. Callister.

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| 01 | 16MTR423 | Group-5 | Vibration Analysis |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**Module 1.**

**Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single dof-system. Force and motion isolation. Two dof-systems: natural frequency.

**Transient Vibration of Single Degree-of Freedom System**: impulse excitation, arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, shock response spectrum, shock isolation, finite difference numerical computation.

**Module 2.**

**Vibration Control**: introduction, vibration isolation theory, vibration isolation theory for harmonic excitation, practical aspects of vibration analysis, shock isolation, dynamic vibration absorbers, vibration dampers.

Vibration measurement and applications: introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis.

**Module 3.**

**Modal Analysis and Condition Monitoring**: dynamic testing of machines and structures, experimental modal analysis, machine condition monitoring and diagnosis.

**Nonlinear vibrations**: introduction, source of nonlinearity, qualitative analysis of nonlinear systems. Phase plane, conservative systems, stability of equilibrium, method of isoclines, perturbation method, method of iteration, self-excited oscillations.

**Module 4.**

**Random Vibrations**: random phenomenon, time averaging and expected value, frequency response function, probability distribution, correlation, power spectrum and power spectral density, Fourier transforms, FTs and response.

**Module 5.**

**Continuous System:** vibrating string, longitudinal vibration of rods, tensional vibration of rods, suspension bridge as continuous system, Euler equation for beams, vibration of membrane.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1) Theory of vibration with application, - William T. Thomson. Marie Dillon dahleh, ChandramouliPadmanaban, 5 edition Pearson Education.
2) Fundamentals of mechanical vibration.-S. Graham Kelly, 2nd edition McGraw Hill.
3) Mechanical Vibrations,-S.S Rao, 4 edition Pearson Education.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 02 | 16MTR13 | Group-5 | ADVANCED CONTROL SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**
Mathematical models of Physical systems, Performance specification, Root locus analysis and design, frequency domain analysis and design.

**MODULE 2**
**Sampled data control systems –** Introduction to con trol systems , Sampling process; Sample and Hold circuit; Types of signals ; Mathematical operation on discrete time signals; Z-transform; Properties of Z-transforms; Inverse Z-transform; Solving the differential equations using Z-transform; and its Applications.

**MODULE 3**
**State space analysis-** concepts of states; State space formulation; State model of linear system; State diagram and signal flow graph; State-space representation using physical variables-Electrical systems and mechanical translational system; State-space model of Mechanical translational systems and Rotational systems.

**MODULE 4**
**Stability, Controllability and Observability-** Linear discrete-time systems(LDS); Transfer function of LDS systems; Stability analysis of sampled data control systems using Jury's stability test, Bilinear transformation and Root locus technique; Similarity transformation; Eigen values and Eigen vectors; Canonical form of state model; Controllability test and Observability test using Gilbert's method of testing, Kalman's te st and Duality property.

**MODULE 5**
**Nonlinear systems-** Introduction to Nonlinear systems; common physical nonlinearities; Describing function; Derivation of describing function of dead-zone and saturation nonlinearity; Derivation of describing function of saturation nonlinearity; Derivation of describing function of dead-zone nonlinearity; Derivation of describing function of relay with dead-zone and hysteresis; Derivation of describing function of Backlash nonlinearity; Describing function analysis of nonlinear systems using polar plot and Nichols plot ; Phase plane and phase trajectories; Singular points; Stability analysis of nonlinear systems using phase trajectories ; Construction of phase trajectories by- analytical method, Isocline method, delta method; Jump response; Liapunov's stability criterion; Popov's stability criterion.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. A. NagoorKani , "Advanced Control Theory" , RBA Pu blications, 2 edition, 1999.
2. J. Nagarath and M.Gopal, "Control Systems Engineering", New Age Internatio nal (P) Limited, Publishers, Fourth edition – 2005
3.Michael Roberts, "Fundamentals of Signals & Systems", 2nd ed, Tata M cGraw-Hill, 2010.
4.Simon Haykin, "Signals and Systems", John Wiley India Pvt. Ltd., 2ndEdn, 2008.

**REFERENCE BOOKS:**

1."Modern Control Engineering ", K. Ogata, Pearson Education Asia/ PHI, 4th Edition, 2002.
2."Feedback and Control System", Joseph J Distefano III et al., Schaum's Outlines, TMH, 2nd Edition 2007.
3."Discrete Time Control Systems", Ogata K., Addison Wesley Longman, 2nd Edition, 2000.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 03 | 16MTR154 | Group-5 | MECHATRONIC SYSTEMS IN AUTOMOBILE ENGINEERING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**
Types of Automobile. Limiting dimensions as per central motor vehicle Rules. Engine classification, construction , Materials of engine components . Prototype testing as per Central Motor Vehicle Rules .

**Module 2**
Fuel System-fuel tank, Fuel filter, Types of fuel system. Carburetor- simple and modern ,fuel injection system. Emission standards as per CMV Rules.

**Module 3**
Electrical System – Storage battery operations and Maintenance. Ignition system - coil and Magneto Ignition system. Starting system, Lighting system , Horn system- wind shield. Wiper Motors, Fans, Heaters,Traficators. Automobile air conditioning, Central Motor Vehicle Rules regarding Lighting, windshields, wipers.

**Module 4**
Transmission system – clutches-operation and fault finding of clutches, Fluid Flywheel ,Gear-Box types, steering systems ,chassis springs, suspension.
Differential Dead and Live axles ,Rims, Tyre etc. Brakes-Types , Construction and fault finding, CMV Rules- Brakes ,Steering & Tyre.

**Module 5**
Lubrication systems- Types, components, Lubricating oil, Cooling system –Details of components, study of systems, Types. Miscellaneous- Special gadgets and accessories for fire fighting vehicles. Automobile accidents.CMV Rules regarding safety devices for drivers, passengers

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**References:**

1) William H Crouse, Automobile chassis and body Construction, Operation and Maintenance.
2) William H Crouse, Automobile Machines –Principles and operations.
3) GBS Narang, Automobile Engineering
4) Kirpalsingh, Automobile Engimeering.
5) Joseph Hietner, Automotive Mechanics- Principles and Practices.
6) P.L.Kohli Automotive Electrical Equipments.
7) The Central Motor Vehicle Rules 1989

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| 04 | 16MTR151 | Group-5 | AUTOMOTIVE ELECTRONICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Automotive fundamentals overview** –four stroke cycle, engine control, ignition system , spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system.Actuators – fuel metering actuators, fuel injector, ignition actuator

**Exhaust After – Treatment System –**AIR, catalytic converter, exhaust gas recirculatio n (EGR), Evaporative emission systems

**Module 2**

**Air/ fuel system –** fuel handling, air intake system, air/ fuel mana gement Sensors:Oxygen (02/EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP) sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure(MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature(ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor

**Module 3**

**Electronic Engine Control** – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control

**vehicle motion control** – cruise control, chassis, power brakes, antilock b rake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension.

**Module 4**

**Communication**-serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS

**Automotive Instrumentation–** sampling, measurement & signal conversion of vari ous parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system

**Module 5**

**Integrated body**- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems

**Automotive diagnostics –** Timing light, engine analyser, on-board diagnosti cs, off- board diagnostics, expertsystems.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**


1. **Willian b. Ribbens:** understanding automotive electronics, 6th edition, SAMS/Elsevier publishing.
2. **Robert Bosch Gmbh:** Automotive electrics automotive electronics systems and components, 5th sedition, john wiley& sons ltd., 2007

**Visvesvaraya Technological University, Belagavi.**
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| 05 | 16MTR251 | Group-5 | FINITE ELEMENT METHODS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, Co C1 and Cn Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.

**Module 2**

**Solid Mechanics :** One-Dimensional Finite Element Formulations and Analysis – Bars- uniform, varying and stepped cross section- Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems.

**Module 3**

**Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems

**Three Dimensional Finite Element Formulations for Solid Mechanics Problems:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements

**Module 4**

**Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements

**Module 5**

**Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.


**Reference Books:**


1. Rao S. S. , Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P.Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3 J.N.Reddy, Introduction to Finite Element Method, McGraw -Hill, 2006.
4. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006..
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 06 | 16MAR424 | Group-5 | CONCURRENT ENGINEERING FOR MANUFACTURING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

Introduction: Introduction. Review of Historical Events. Push and Pull for New Paradigms. Areas of Manufacturing Competitiveness. Product and Services. Process and Methodologies. Performance Indicators, Manufacturing Competitiveness.

**Life-Cycle Management:** Shrinking Life Cycle. Life-Cycle Management.New Product Introduction.Strategic Technology Insertions.ManagingContinuity.Managing Revision Changes.Life-Cycle Cost Drivers.Life-Cycle Management Tools.Sequential Versus Concurrent Engineering.Life-Cycle Management.

**Module 2**

**Process Reengineering:** Understanding and Managing Change, Reengineering Approaches. Tenents of Process Improvement. Work Flow Mapping. Information Flow-Charting. Enterprise Models. Process Improvement Methodology. Change Management Methodology. Concurrent Process Reengineering.

**Module 3**

**Concurrent Engineering Definitions: I**ntroduction, CE Definitions. Basic Principles of CE. Components Of CE. Concurrency And Simultaneity. Modes of Concurrency. Modes of Cooperation. Benefits Of Concurrent Engineering. 8 Hours

**Module 4**

**System Engineering :**Introduction. An Automobile Manufacturing Process. System Engineering. Systems Thinking. Approaches to System Complexity. Sharing and Collaboration in CE 300. System Integration. Agile Virtual Company.

**Module 5**

**Information Modeling :**Information Modeling. Modeling Methodology. Foundation of Information Modeling. Concurrent Engineering Process Invariant. Enterprise Model-Class. Specification Model-Class. Product Model-Class. Process Model- Class. Cognitive Models. Merits and Demerits.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1.“Concurrent Engineering Fundamentals -Integrated product and process organization”- Vol I & II, Prasad.B, PHI..

2. “Concurrent Engineering”- Shortening lead times, Raising Quality and Lowering Costs, Johan.R. Hartely, Productivity press, Portland, Oregon 1992.

**Reference Books :**

1.“Concurrent Engineering” -The Product Development Environment for the 1990’s, Carter DE and Baker BS, Addison Wesley Publishing Company.

2.“Concurrent Engineering in Product Design and Development”- Editor-Imad Moustapha,Reprint-2006, New Age International Publishers

**Visvesvaraya Technological University, Belagavi.**
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| 07 | 16MEA424 | Group-5 | COMPUTATIONAL FLUID DYNAMICS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Basic Concepts -** Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy).

**MODULE 2**

**Finite Difference Methods** - Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples.

**MODULE 3**

**Finite volume method - S**urface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples

**MODULE 4**

**Gausian Elimination;** LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods.

**Multi-grid method -** Coupled equations; Simultaneous solutions, sequential solutions & under relaxation. Non linear systems

**MODULE 5**

Initial value problem & Boundary value problems; Implicit & Explicit Schemes; 2D and 3D examples. Heat and Mass transfer Problems; Multi Phase Flows.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., - G.D. Smith, Oxford University Press. 1986.

**Reference Books**

1. Computational Fluid Dynamics - T. J. Chung, Cambridge Univ. Press, 2002.
2. Partial Differential Equations for Scientists and Engineers - Farlow, John Wiley, 1982.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 08 | 16MTR152 | Group-5 | MICRO AND SMART SYSTEMS TECHNOLOGY |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**

**Introduction:**

a)What are smart material systems? Evolution of smart materials, structures and systems. Components of a smart system. Application areas. Commercial products.

b) What are microsystems? Feynman's vision. Micromachiend transducers. Evolution of micro-manufacturing. Multi-disciplinary aspects. Applications areas. Commercial products.

**Micro and smart devices and systems: principles and materials:**

a) Definitions and salient features of sensors, actuators and systems.

b) Sensors: silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyser, conductometric gas sensor, fiber=optic gyroscope and surface acoustic – wave based wireless strain sensor.

c) Actuators : silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic com-drive and micromotor, magnetic micro relay, shape memory-alloy based actuator, electro-thermal actuator

d) Systems: micro gas turbine, portable clinical analzer, active noise control in a helicopter cabin.

**Module 2**

**2. Micro-manufacturing and material processing:**

a) Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding and metallization.

b) Silicon micromachining: surface, bulk, moulding, boding based process flows.

c) Thick-film processing:

d) Smart material processing:

e) Processing of other materials: ceramics , polymers and metals

f) Emerging trends

**Module 3**

**Modelling:**

a) Scaling issues.

b) Elastic deformation and stress analysis of beams and plates. Residual stresses and stress gradients. Thermal loading. Heat transfer issues. Basic fluids issues.

c) Electrostatics. Coupled electro-mechanics. Electromagnetic actuation. Capillary electo-phoresis. Piezoresistivemodelling. Piezoelectric modelling. Magnestrictive actuators.

**Computer- aidded simulation and design:** Background to the finite element method. Coupled-domain simulation using Matlab. Commercial software.

**Module 4**

**Electronics, circuits and control:**

Carrier cocentartions, semiconductor diodes, transistors, MOSFET amplifiers, operational amplifiers. Basic Op-Amp circuits. Charge-measuring circuits. Examples from microsystems. Transfer function, state- space modelling, stability, PID controllers, and model order reduction. Exmples from smart systems and micromachined accelerometer or a thermal cycler

**Module 5**

**Integration and packing of microelctro mechanical systems:**

Integration of microelectronicsmicro devices at wafer and chip levels. Microelectronic packaging: wire and ball bonding, flip-chip. Low temperature-corfired-ceramic (LTCC) multi-chip-module technology. Microsystem packaging examples.

**Case studies:**

BEL pressure sensors, thermal cycler for DNA amplification and active vibration control of a beam.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. Mein Schwartz:**"Composite Materials handbook" -** Mc Graw Hill Book Company, 1984.
2. Autar K. Kaw CRC**: "Mechanics of composite materials" -** Press New York.

**REFERENCE BOOKS:**

1. Rober M. Joness:**"Mechanics of Composite Materials" -** Mc-Graw Hill Kogakusha Ltd.
5. Michael W, Hyer:**"Stress Analysis Of Fiber Reinforced Composite Mate rials"-** Mc-Graw Hill International.
6. Krishan K. Chawla Springer.:**"Composite Material Science and Engineering"**
7. P.C. Mallik Marcel Decker:**"Fibre Reinforced Composites"**

**Visvesvaraya Technological University, Belagavi.**
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| 09 | 16MCM22 | Group-5 | FLEXIBLE MANUFACTURING SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1.Introduction** Flexible and rigid manufacturing, F.M. Cell and F.M. System concept, Types and components of FMS, Tests of flexibility, Group Technology and FMS, unmanned factories, Economic and Social aspects of FMS.

**Module 2.Control structure of FMS**: Architecture of typical FMS, Automated work piece flow, Control system architecture – Factory level, Cell level; hierarchical control system for FMS, LANs - characteristics, transmission medium, signaling, network topology, access control methods; Factory networks, Structure and functions of manufacturing cell, Distributed Numerical Control (DNC ).

**Module 3. Scheduling & Loading Of FMS:** Introduction, Scheduling of operations on a single machine, 2 machine flow shop scheduling, 2 machine job shop scheduling, 3 machine flow shop scheduling, scheduling 'n' operations on 'n' machines, Scheduling rules, loading problems , Tool management of FMS, material Handling system schedule. Problems.

**Module 4.Tooling in FMS**: Modern cutting tools and tool materials, tool holders, modular tooling, tool monitoring, presetting and offsets, wear and radius compensation, tool magazines, automatic tool changers, robotized tool assembly, tool management system.

**Module 5.Fixturing in FMS**: Part holding on Pallets, standard fixtures, pallet changers, pallet pool, flexible fixturing – principles and methodologies, modular fixturing system: T slot based, dowel pin based, fixturing components, computer aided fixture design – locating and clamping, use of GT in fixture design, fixture database

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**


1. Groover, Mikell P. (2002), 2/e, **" Automation, Production Systems & Computer Integrated Manufacturing",** Pearson Education or PHI
2. Viswanadhan, N. & Narahari, Y. (1998), **"Performance Modelling of Automated Manufacturing Systems",** PHI
3. Pinedo, Michael & Chao, Xiuly (1999), **"Operations Scheduling with Applications in Manufacturing & Services",** McGraw Hill International Editions (with 2 Floppy Disks of LEKIN Scheduling Software)


**Reference Books**


1. Kelton, Sadowsky & Sadowsky, "Simulation with ARENA",2/e, McGraw Hill International Editions (with CD of ARENA Simulation Software)
2. Radhakrishnan, Subramanyan, "CAD / CAM / CIM", John Wiley
3. Rao, PN, Tewari NK, Kundra TK, "Computer Aided Manufacturing", TMH
4. Rong, Yeming; "Computer Aided Fixture Design", Marcel Dekker, ISBN 0-8247-9961-5 5. Hobbs, "Lean Manufacturing Implementation", J. Ross Publishing, ISBN 1-932150-14-2 6. Chowdiah, Gargesa & Kumar, "Agile Manufacturing", TMH

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| 10 | 16MST421 | Group-5 | MODELING, SIMULATION AND ANALYSIS OF MANUFACTURING SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1**
**Principles of Modeling & Simulation:** Basic Simulation Modeling, Limitation of Simulation, Monte - Carlo Simulation, Areas of Applications, Discrete and Continuous Systems.

**Module 2**
**Modeling Approaches:** Modeling Complex Systems, Simulation Software, Basics Probability and Statistics, Building Valid and Credible Simulation Models

**Module 3**
**Random Number and Variable Generation:** Selecting Input Probability Distributions, Random Number Generators, Generating Random Variants, and Output Data Analysis for a Single System.

**Module 4**
**Statistical Techniques:** Comparison of Alternative Systems, Variance Reduction Techniques.

**Module 5**
**Simulation Studies:** Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1.Simulation, Modeling and Analysis –Averill Law & David M.Kelt on, TMH 3rd Edition.
2.Discrete event and Simulation Systems – Banks & Carson, Prentice Hall Inc.

**Reference Books:**

1. "System Simulation" - Gordon, PHI.
2. "System Simulation with Digital computer" – Deo, PHI
3. "Computer Simulation And Modeling" – Francis Neelamkovil, John Wiley & Sons.

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| 11 | 16CAE251 | Group-5 | DESIGN OPTIMIZATION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.

**Applications of Optimization in Engineering Design:** Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.

**Module 2. Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non Linear Optimization.

**Optimization Theory** – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions.

**Module 3. Sensitivity Analysis:** Linear and Non Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.

**Optimization Disciplines:** Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

**Module 4. Manufacturability in Optimization Problems:** Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

**Design Interpretation:** Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum .

**Module 5. Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. S.S.Rao, Engineering Optimization: Theory and Practice, John Wiley, 2009
2. JasbirArora, Introduction to Optimum Design, McGraw Hill, 2011.

**Reference Books:**

1. Optimisation and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

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| 12 | 16MTR421 | Group-5 | ARTIFICIAL INTELLIGEN CE & NEURAL NETWORKS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1.**
**Introduction,** history, structure and function of Single neuron, neural network architectures, neural learning, use of neural networks. Supervised learning, single layer networks, perceptions, linear separability, perceptions training algorithm, guarantees of success, modifications.

**Module 2.**
**Multiclass networks-I,** multilevel discrimination, preliminaries, back propagation, setting parameter values, theoretical results.

**Module 3.**
**Accelerating learning process,** application, mandaline, adaptive multilayer networks. Prediction networks, radial basis functions. Polynomial networks, regularization, unsupervised learning, winner take all networks

**Module 4.**
**Learning vector quantizing,** counter propagation networks, adaptive resonance theorem, toplogically organized networks, distance based learning. neo-cognition.

**Module 5.**
**Associative models,** hop field networks, brain state networks, Boltzmann machines, hetero - associations. Optimization using hop filed networks, simulated annealing, random search, evolutionary computation.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXTBOOK:**
**I.** Elements of Artificial Neural Networks, Kishan Mehrotra, C. K. Mohan,SanjayRanka. Penram, 1997, .
**REFERENCE BOOKS:**
1. Artificial Neural Networks, R. Schalkoff, MGH, 1997.

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| 13 | 16MTR21 | Group-5 | ADVANCED ELECTRONIC DRIVES |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1 DC Motors-** Classification, Back EMF equation, Torque equation, Characteristics of shunt, series & compound motors, speed control by armature voltage control, field control ,ward Leonard method.
**Synchronous machines-** Basic principle of operation, construction of salient & non-salient pole synchronous machines, generated EMF, effect of distribution of winding and use of chorded coils. Voltage regulation, Voltage regulation by EMF, MMF, ZPF & ASA.

**MODULE 2 An introduction to electrical drives & its dynamics:** Electrical drives. Advantages of electrical drives. Parts of electrical drives, choice of electrical drives, status of dc and ac drives, Dynamics of electrical drives, Fundamental torque equation, speed torque conventions and Multiquadrant operation. Equivalent values of drive parameters, components of low torques, nature and classification of load torques, calculation of time and energy loss in transient operations, steady state stability, load equalization.

**MODULE 3 Dc motor drives** Starting braking, transient analysis, single phase fully controlled rectifier,control of separately excited,Dc motor, Single-phase half controlled rectifier control of separately excited dc motor.Selection of motor power rating: Thermal model of motor for heating and cooling,Classes of motor duty, determination of motor rating.10 Hours

**MODULE 4 Three phase induction machines:** Concept of rotating magnetic field. Principle ofOperation, construction, classification and types - single-phase, three-phase, squirrel-cage, slip-ring.Slip,Torque, torque-slip characteristic covering motoring, generating and braking regions of operation.Maximum torque.

**MODULE 5Induction motor & synchronous motor drives**

Operation with unbalanced source voltage and single phasing, operation with unbalanced rotor impedances,Analysis of induction motor fed from non-sinusoidal voltage supply, starting braking, transient analysis, Operation from fixed frequency supply, synchronous motor, Variable speed drives, variable frequency control of multiple synchronous motors.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**

1. Fundamentals of Electrical Drives, G.K Dubey , Narosa publishing house, 2nd Edition,2002.

**REFERENCE BOOKS:**

1. Electrical Drives, N.K De and P.K. Sen- PHI, 2009.
2. A First Course On Electric Drives, S.K Pillai-Wiley Eastern Ltd 1990.
3. Power Electronics, Devices, Circuits and Industrial Applications, V.R. Moorthi, "Oxford University Press, 2005.
4. Electric Motor Drives,Modeling,Analysis and Control, R.Krishnan,PHI,2008.

**Visvesvaraya Technological University, Belagavi.**
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| 14 | 16MTR23 | Group-5 | SENSORS AND SIGNAL CONDITIONING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. INTRODUCTION TO MEASUREMENT SYSTEM**: General Concepts and Terminology, Sensors Classification, General Input-Output Configuration, Static Characteristics of Measurement Systems, Dynamics Characteristics of Measurement Systems, Input Characteristics: Impendence, Primary Sensors, Problems.

**RESSISTIVE SENSORS:** Potentiometers, Strain Gages, Resistive Temperature Detectors (RTDs), Thermistors, Magneto resistors, Light Dependent Resistors (LDRs), Resistive Hygrometers.

**Module 2. SIGNAL CONDITONING FOR RESISTIVE SENSORS**: Measurement of Resistance, Voltage Dividers, Wheatstone bridge, Balance Measurements, Instrumentation Amplifiers, and Interference.

**REACTIVE VARIATION AND ELECTROMAGNETIC SENSORS**: Capacitive Sensors, Inductive Sensors, Electromagnetic Sensors.

**Module 3. SIGNAL CONDITIONING FOR REACTIVE VARIATION SENSORS:** Problems and Alternatives, AC Bridges, Carrier Amplifiers, variable Oscillators, Resolver – to Digital and Digital-to-Resolvers Converters.

**SELF- GENERATING SENSORS:** Thermoelectric Sensors: Thermocouples, Piezoelectric Sensors, Photovoltaic Sensors, Electro chemical Sensors.

**Module 4. SIGNAL CONDITIONING FOR SELF- GENERATING SENSORS:** Chopper and Low-Drift Amplifiers, Electrometer Amplifiers, Charge Amplifiers, Noise in Amplifiers.

**DIGITAL SENSORS:** Position Encoders, Variable Frequency Sensors.

**Module 5. OTHER TRANDUCTION METHODS:** Sensors based on Semiconductors Junctions, Sensors based on MOSFET Transistors, Charge-Coupled Sensors, Ultrasonic- based Sensors, Fiber-Optic Sensors.

**TELEMETRY AND DATA ACQUISTION:** Data- Acquisition System Structure, Telemetry Systems, Amplitude Telemetry, Frequency Telemetry.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Book:**

1. Sensors and Signal Conditioning, Ramon Pallas Areny, JohnG.Webster, John Wiley and Sons,1991.

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 01 | 16MCM153 | Group-6 | RAPID PROTOTYPING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction:** Definition of Prototype, Types of prototype, Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems.
**Stereo lithography Systems:** Principle, Process parameter, process details, Data preparation, data files and machine details, Application.

**Module 1. Selective Laser Sintering:** Type preparation for SLS, Applications, Path generation, Applications. Principle of operation, process parameters, Data Fusion Deposition Modeling**:** Principle, Process parameter.

**Module 3. Solid Ground Curing:** Principle of operation, Machine details, Applications, Laminated Object Manufacturing: Principle, of operation, LOM materials, process details, application.
**Concepts Modelers:** Principle, Thermal jet printer, Sander's model market, 3-D printer, Genisys Xs printer HP system 5, object Quadra systems, Laser Engineering Net Shaping.

**Module 4. Rapid Tooling :**Indirect Rapid tooling -Silicon rubber tooling —Aluminum filled epoxy tooling Spray metal tooling ,Cast kirksite ,3D keltool ,etc .Direct Rapid Tooling — Direct, AIM, Quick cast process, Copper polyamide, Rapid Tool ,DMILS, ProMetal ,Sand casting tooling ,Laminate tooling soft Tooling vs. hard tooling.

**Module 5. Software for Rp:** Stl files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools
**Application of Rapid Prototyping and Technology:-**Functional models, pattern for investment and Vacuum casting, medical models, Art models, Engineering analysis models.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Paul F. Jacobs: " Stereo 1ithography and other RP & M Technologies"-SME NY, 1996.
2. Flham D.T &Dinjoy S.S " Rapid Manufacturing"- Verlog London 2001.

**Reference Books:**

1. Terry Wohler's " Wohler's Report 2000 "- Wohler's Association 2000

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| 02 | 16MCM154 | Group-6 | AGILE MANUFACTURING |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Agile Manufacturing:** Definition, business need, conceptual frame work, characteristics, generic features. Four Core concepts: Strategy driven approach-integrating organization, people technology, interdisciplinary design methodology. 6Hours

**MODULE 2**

**Developing Agile Manufacturing:** Enterprise design, System concepts as the basic manufacturing theory-joint technical & Organizational design and a model for the design of agile manufacturing enterprise. Enterprise design process insights into design processes, what is interdisciplinary design, main issues, simple design example.

**Integration of Product /Process Development:** Principles, Robust design approach, manufacturing, Role of QFD, Managing people in Agile organization, Approaches.

**MODULE 3**

**Application of IT/IS Concepts In Agile Manufacturing:** Strategies, Management of complexities and information. flow, approaches, applications of multimedia to improve agility in manufacturing, system concepts.

**Agile Supply Chain Management:** Principles, IT/IS concepts in supply chain management, enterprise integration and management in agile manufacturing, concepts, Agility, Adaptability and learners – comparison of concepts.

**MODULE 4**

**Computer Control Of Agile Manufacturing:** CAPP for Agile Manufacturing, Aggregate capacity planning and production line design / redesign in Agile manufacturing, Cellular manufacturing, concepts, examples.

**Corporate Knowledge Management In Agile Manufacturing:** Strategies, strategic options in Agile manufacturing, Role of standards.

**MODULE 5**

**Design of Skill & Knowledge:** Enhancing technology for Machine tool system, Resumption of design requirement geometry, definition, methods, decision support for selection of cutting parameters, design enhancements, parametric approach only**.**

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**


1. Agile Manufacturing - Forging Mew Frontiers', Poul T Kidd, Amagow Co. UK, ISBN-0-201-63163-6, 1994.
2. Agile Manufacturing", A Gunasekharan, the 21stCenturyCompetitive strategy, ISBN -13 978-0-08-04 3567-1, Elsevier Press, India.


**REFERENCE BOOKS:**


1. O Levine Transitions to Agile Manufacturing, Joseph C Moutigomery and Lawrence – Staying Flexibl e for competitive advantage, ASQC quality press, Milwaukee. Wisconsin, USA, 1996.

2. Agile Development for Mass Customization, David M Anderson and B Joseph Pine, Irwin Professional Publishing, Chicago, USA, 1997.

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| 03 | 16MAR155 | Group-6 | MODELING OF MANAGEMENT INFORMATION SYSTEMS |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module 1.**

**Information Basics:** Definition of information system, classification of IS, Need for Information system, Contemporary approaches to information system, Key system applications in the organization, Challenges of information systems. Impact of IT, IS for Knowledge work.

**Module 2**

**Managing with Information and its Resources**: Managing in 21st Century, Strategic planning and IS, Information needs for strategic planning, IS for decision support, Quality and privacy issues. Information resource management, strategic planning for IS function, justification for IS, IT/IS facilities and operations, security control and Audit.

**Module 3.**

**Information systems and Organizations:** Relationship between organizations and information systems, feature of organizations, effect of organizations on information systems, effect of information systems on organizations.

**Information, Management and Decision-making:** Role of managers, Decision-making, Individual models of decision-making, Organizational models of decision-making.

**Module 4.**

**Information System Development:** system development life cycle and methodologies, principles of system design. System analysis- Definition, Strategies and Phases.

**Object Oriented Technology:** Object orientation, object oriented analysis (OOA),system development through OOT, Object Oriented Languages. OOT and MIS.

**Module 5.**

**System modeling:** Introduction to system modeling, system concepts for data modeling,
logical data modeling, and construction of data model. Process modeling: Introduction to process modeling, system concepts for process modeling, data flow diagram, logical process modeling, construction of process model.

**Decision Support Systems:** DSS issues, Structure Constructions-approaches, generators, tools, software and cost benefits and simple examples of applications

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


1. Management information systems organization and technology, 4th edition - Kenneth C.Laudon and Jane P.Laudon, , Prentice Hall India/Pearson Education.
2. Systems analysis and design methods, 4th edition - Jeffery L.Whitten and LonnieD.Bentley, Tata McGraw Hill.


**Reference Books:**


3. Management Information Systems-Conceptual foundations, Structure and development - Davis.G.B, McGraw Hill Intl.Book.Co.
4. Management Information Systems - Robert Schulties and Marry summer, Tata McGraw Hill Publishing Co., Ltd. New Delhi.
5. Management Information System- A Concise Study - S.A.Kelkar, PHI.
6. Management Information systems - W.S Jawadekar, TMH
7. Information System for modern management -Murdick Ross &Claggett ,PHI.

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| | | | |
|---|---|---|---|
| **04** | **16MTR253** | **Group-6** | **PRODUCT DESIGN** |
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. DEVELOPMENT PROCESSES AND ORGANIZATION :** Characteristics of successful product development, Design and development of product, Duration and cost of product development, the challenges of product development, A generic development process, concept development: the front-end process, adopting the generic product development process, the AMF development process, product development organization, the AMF organization.

**Module 2. PRODUCT PLANNING, IDENTIFYING CUSTOMER NEEDS AND PRODUCT SPECIFICATION**: The product planning process, identifying opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and process.
Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into o hierarchy, establish the relative importance of the needs and reflect on the results and the process. What are specifications, when are specifications establishing target specifications, setting the final specifications.

**Module 3. CONCEPT GENERATION, SELECTION AND TESTING:**
The activities of concept generation clarify the problem, search externally, search internally, explore systematically, reflect on the results and the process. Overview of concept selection methodology, concept screening, and concept scoring, Definition and the purpose of concept test, choose a survey population, choose a survey format, communication the concept, measure customer response, interpret the result, reflect on the results and the process.
**PRODUCT ARCHITECTURE:**
What is product Architecture, implications of the Architecture, Establishing the Architecture, Variety and supply chain considerations, platform planning, and related system level design issues.

**Module 4. INDUSTRIAL DESIGN:** Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design.
**DESIGN FOR MANUFACTURING AND PROTOTYPING:** Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production basics, principles of prototyping, technologies, planning for prototypes.

**Module 5. PRODUCT DEVELOPMENT:** Elements of economic analysis, base case financial mode, sensitive analysis, project trade- offs, influence of qualitative factors on project success, qualitative analysis.
**MANAGING PROJECTS:** Understanding and representing task, baseline project planning, accelerating projects, project execution, postmortem project evaluation.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Book:**
Product Design and Development by Karl T Ulrich, Steven D Eppinger, Anita Goyal.

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| 05 | 16MCS253 | Group-6 | Project Analysis and Management |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**Module 1**

**Introduction:** Capital Investments, types of Capital Investments, Phases of Capital Budgeting, Phases of Capital Budgeting, Levels of Decision Making, Facets of Project Analysis, Feasibility study, Weakness in Capital Budgeting.

**Market and Demand Analysis:** Situational Analysis and objectives specification, Collection of Information, Market survey, Market characterization, Demand Forecasting, Qualitative, Quantitative and Casual Methods of Forecasting, Uncertainties in demand forecasting, Market Planning.

**Module 2**

**Technical Analysis:** Manufacturing Technology, Material Inputs, Product Mix, Plant Capacity, Location, Machineries and equipment, Structure and civil works, Environmental Aspects, Project charts and layouts, Project implementation, consideration of alternatives.

**Financial Analysis:** Cost of project, Means of Finance, Estimation of sales and production, cost of production, working capital requirements and financing, Profitability projections, Breakeven Analysis, Cash Flow and Balance sheet statements.

**Module 3**

**Investment Analysis:** Time value of Money, Interest factors, Compounding and Discounting, Investment criteria – NPV, BCR, IR R, Payback Period, Urgency, ARR, Investment Evaluation.

**Risk Analysis:** Sources, Measures and perspective of Risk, Sensitivity Analysis, Simulation Analysis, Decision Tree Analysis, Monte- Carlo Simulation, Project selection under Risk.

**Module 4**

**Networks Techniques for Project Management:** Project Network, Time estimation, Critical Path determination, PERT/CPM Model, Network cost system.

**Module 5**

**Manpower Management in Projects:** Functional Approach to Manpower Management- the element of decision process, project team concepts, filed autonomy, policies, government policies.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

1. Prasanna Chandra: “Projects - Appraisal, Preparation, Budgeting And I mplementation” -
2. James P,Lewis: “Project Planning, Scheduling & control”- ,Meo Publishing company. 2001
Tata McGraw hill.

**REFERENCE BOOKS:**

1. Dennis lock: “Hand book of Project Management ”
2. Dennis lock: “Project Management”.
3. Hardd kerzner :“Project Management A System Approach To Planning Scheduling And Controlling” -CBS Publishers and distributors. 2002
4.Beningston Lawrence: “Project Management” - Mc-Graw hill 1970

**Visvesvaraya Technological University, Belagavi.**
**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 06 | 16MDE154 | Group-6 | DESIGN FOR MANUFACTURE |
|---|---|---|---|
| Exam Hours:03 | | Exam Marks:100 | |

**MODULE 1**

Effect of Materials And Manufacturing Process On Design: Major phases of design. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, Weighted properties and limits on properties methods.

Tolerence Analysis: Process capability, mean, varience, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance-Sure fit law and truncated normal law.

**MODULE 2**

Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups - Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples

Datum Features : Functional datum, Datum for manufacturing, Changing the datum. Examples

**MODULE 3**

Design Considerations: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviates and cores.

Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations.

**MODULE 4**

True positional theory : Comparison between co-ordinate and convention method offeature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging.

**MODULE 5**

Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. Harry Peck , “Designing for Manufacturing”, Pitman Publications, 1983.
2. Dieter , “Machine Design” - McGraw-Hill Higher Education, -2008
3. R.K. Jain, "Engineering Metrology", Khanna Publishers, 1986
4. Product design for manufacture and assembly - Geoffrey Boothroyd, Peter dewhurst, Winston Knight, Merceldekker. Inc. CRC Press, Third Edition
5. Material selection and Design, Vol. 20 - ASM Hand book.

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| 07 | 16MTR422 | Group-6 | RELIABILITY AND FAILURE ANALYSIS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1.**

**Reliability definition** - introduction, definition, failure data, mean failure rate, mean time to failure, mean time between failure, graphical plots, four important points, mttfinterms of failure density, generalization, reliability in terms of hazard rate and failure density, int integral form, mean time to failure in integral form, reliability in other situations.

**Module 2.**

**Hezard models;** constant hazard, linearly increasing hazard, the weibull model, on density function and distribution function, distribution function and reliability analysis, some important distributions, choice of distribution, expected value, standard deviation and variance, theorems concerning expectation and variance.

**Module 3.**

**Conditional probabilities and multiplication rule,** independent events, venn diagrams-sample Space, probability calculation by venn diagrams, system reliability, series configuration, parallel and mixed configuration, application to Specific hazard models, anr-out-of-n structure, method of solving complex System, system not reducible to mixed configurations, mean time to failure of Systems, logic diagrams, markov models, markoy graphs, system Subjected to probability laws.

**Module 4.**

**Reliability improvement,** improvement of components, redundancy, element redundancy, unit redundancy, stand by redundancy, optimization, reliability-cost trade-off, fault tree analysis and other techniques, fault free construction, calculation of reliability from fault tree, tie-set and cut-set, use of Boolean algebra, basic operations, truth tables; demorgan's theorem, application to reliability analysis, probability calculations.

**Module 5.**

**Maintainability,** availability (qualitative aspects) system down time, availability, reliability and maintainability trade-off, instantaneous repair rate, mean time to repair, reliability and availability functions, reliability allocation and applications, reliability allocation for a series System, applications, marine power plant, computer system, nuclear power plants, general complex systems, failure modes and effect analysis.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**:

I. Reliability engineering, L.S.Srinath, A ffilated cast-West Press Pyt Ltd, New Delhi.
2. Quality planning and analysis, Juran.J.M and Gryna.F.M, Tata Mcgraw hill Publishing company Ltd, Delhi, India. Edition 2000
4 Reliability engineering, Balaguruswamv. Tata Mcgraw Hill, Fourth edition, 2003.

**Reference Books**

1. The Assurance Sciences. Halpern, Seimund, Prentice hall International, New Jersey, USA 1978,
2. Hand book of Reliability engineering and Management, Kraus, John W (1988)Ireson. W.G and Cooms.CF, Mcgraw Hill Book Company Inc.USA.

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| 08 | 16MTP152 | Group-6 | Nuclear Energy Conversion |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Nuclear Fuel and Reactor Theory**: Nuclear fuels - Occurrence and extraction – Fissile characteristics – Enrichment - Fission process - Thermal and fast fission – Energy released from fission - Chain reaction -Reaction control. Neutron balance - Fast fission - Resonance capture – Thermalization - Geometric effects - Burn-up – Introduction to reactor kinetics.

**Module 2. Nuclear Reactors**: General components of nuclear reactor - Fuel cladding – fuel assembly – moderators – coolants - control rods -Different types of reactors -Pressurized Water Reactor - Boiling Water Reactor - Heavy Water cooled Reactor – Gas cooled Reactor - Liquid metal cooled reactor - Organic moderated and cooled reactors - Fast Breeder Reactors - Reactor safety - Neutron Population growth - Assurance of safety - Emergency core cooling and containment.

**Module 3. Radioactive Waste Management:** The nuclear fuel cycle - Waste classification – Spent fuel storage – Transportation – Reprocessing - High-Level waste disposal - Low-level waste generation and treatment -Low-level waste disposal - Nuclear power plant decommissioning.

**Module 4.** exposure - Sources of radiation dosage - Gas counters – Neutron detectors - Scintillation counters - Solid state detectors - Statistics of counting – Pulse height analysis - Protective measures - Calculation of dose - Effects of distance and shielding - Internal exposure - The Radon problem – Environmental radiological impact -Radiation standards.

**Module 5. Nuclear Power for Propulsion and Energy Economics:** Reactors for naval propulsion- Space reactors - Space isotopic power generator - Energy economics - Components of electrical power – cost forecast versus Reality - Challenges and opportunities – Technical and institutional improvements – Developments in nuclear reactor.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING:**

1. Nuclear Energy, Charles, D. Furguson, First Edition, Oxford University press,2011.
2. Nuclear Power Technology, W.Marshall, Vol. I &II, Clarendon press, Oxford, 1985.
3. Principle of Nuclear Reactor Engine, SamualGlasstone, Van Nostrand Reinhold Co. Inc., New York, 1963.
4. Nuclear Power Station, Margulova, Mir Publishers, Moscow, 1978.
5. Principle of Energy Conversion, Archie W.Culp, McGraw Hill Kogakusha Ltd., 1984.
6. A Course in Power Plant Technology, Domkundwar, Dhanpat Rai Sons

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| 09 | 16MCM252 | Group-6 | CONCURRENT ENGINEERING AND PRODUCT LIFE CYCLE MANAGEMENT |
|---|---|---|---|

**Exam Hours:03** | **Exam Marks:100**

**Module 1. Introduction:** Extensive definition of Concurrent Engineering(CE),CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA(Design for assembly),QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, organizing for CE, CE tool box, Collaborative product development.

**Module 2. Use of Information Technology**: IT Support Solid modeling, product data management, Collaborative product commerce, Artificial Intelligence, expert systems, Software hardware component design**.**

**Module 3. Design Stage:** Lifecycle design of products, opportunities for manufacturing enterprises, Modality of Concurrent engineering design, Automated analysis idealization control, CE in optimal structural design, Real time constraints**.**

**Module 4. Need for PLM:** Importance of PLM, Implementing of PLM, Responsibility for PLM, Benefits to different managers, Components of PLM, Emergence of PLM, Life cycle problems to resolve, Opportunities to seize**.**

**Module 5. Components of PLM:** components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Book**


1. Integrated Product Development / M.M .Anderson and L.Hein/ IFS Publications.
2. Design for Concurrent Engineering/ J Cleetus/ CE Research Centre, Morgantown.
3. Concurrent Engineering Fundamentals/ Prasad / Prentice hall India Integrated Product Development.
4. Concurrent Engineering in product Design and Development/ I.Moustapha / New age International


**REFERENCE BOOK**


1. Product Life Cycle Management/ John Stark/ Springer –Verlag/ UK.
2. Product Lifecycle Management/ Michael Grives/ Mc Graw Hill
3. Concurrent Engineering: Automation tools and Technology/Andrew Kusiak/ Wiley Eastern Technology.

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| 10 | 16MAR23 | Group-6 | COMPUTER CONTROL OF MANUFACTURING SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | | **Exam Marks:100** |

**Module 1.Introduction to Computer integrated Manufacturing Systems:** Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems,
**Fundamentals of Numerical Control:** Basic concepts of NC, Classification of NC- Point to Point and contouring, Incremental and absolute system, Open loop and closed loop system, Advantages of NC.

**Module 2. NC/ CNC Machine Tools:** General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit , CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feedback Devices: Encoder, Resolver, Inductosyn, Tachometers, Counting devices.
**Constructional Features of CNC Machines:** Design considerations of CNC machines for improving machining accuracy, Structural Members, Slide ways, bearings, Re-circulating ball Screws, Spindle drives, Work holding devices and tool holding devices, Automatic tool changers.

**Module 3. N.C part programming:** Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming.
**Computer Controls in NC**: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control(DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC,

**Module 4**. **Adaptive control**: machining systems. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control Machining.
**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.

**Module 5**. **Computerized Manufacturing Planning and Control Systems:** Computer aided process planning, Variant and Generative approaches, Computer integrated production planning and control systems, Typical production planning and control system, Material planning systems, Capacity planning, Shop Floor Control, Automatic identification, Automated data collection systems.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


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


**Reference Books:**


1. Martin J. -**Numerical control of machine tools.**
2. P.N. Rao – CAD/CAM **Principles and Applications**McGrawhill 2002
3. Y. Koren&J.Benuri -**"Numerical control of machine tools** -Khanna, 1992
4. Wilson F.M **—Numerical control in manufacturing**- McGraw Hill Newyork
5. Suk-Hwan Suh, Seong-Kyoon Kang, Dea-Hyuk Chung and Ian Stroud, **Theory and Design of CNC Systems**, , Springer, 2008

**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

| **11** | **16MCS13** | **Group-6** | **OPTIMIZATION TECHNIQUES** |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**Module 1. Introduction:** Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, Classical optimization techniques I: single variable optimization, Multivariable optimization with no constraints.

**Classical Optimization Techniques II:** Multivariable optimization with equality constraints and inequality constraints, Kuhn – Tucker conditions.

**Module 2. Non - linear Programming:** One - dimensional minimization methods: Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Fibonacci method, Golden section method.

**Interpolation Methods:** Quadratic, Cubic and Direct root interpolation methods.

**Module 3. Unconstrained Optimization Techniques**: Direct search methods : Univariate method, Hook and Jeeves' method, Powell's method, Simplex method.

**Descent Methods:** Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method.

**Module 4. Constrained Optimization Techniques**: Direct methods: characteristics of a constrained problem, Indirect methods: Transformation techniques, Basic approach of the penalty function method.

**Module 5. Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

**Question paper pattern:**

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- Each full question consists of 20 marks.
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- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. S. S. Rao, Optimisation: "Theory **and Application" -** Willey Eastern.
2. R.L Fox: "Optimization **methods for Engg. Design" -** Addison - Wesley.

**Reference Books:**

1. Ram:" **Optimisation and Probability in System Engg" -** Van Nostrand.
2. K. V. Mital & C. Mohan: **"Optimization methods"** - New age International Publishers, 1999.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
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| 12 | 16MAR 423 | Group-6 | TOOLING FOR MANUFACTURE IN AUTOMATION |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

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

**Modern Cutting tool materials:** Material properties, HSS related materials, sintered tungsten carbide, cermets, ceramics, polycrystalline tools, tool coatings, coating methods, conventional coating materials, diamonds and CBN

**Cutting tools:** Basic types of cutting tools, turning tools, indexable inserts, groove geometry, edge preparation, wiper geometry, insert clamping methods, tool angles, threading tools, grooving and cut off tools, milling tools, types of milling cutters, milling inserts and edge clamping methods.

**MODULE 2**

**Optimization:** Machining cost and production rate verses cutting speed, role of computerized optimization system, economic considerations, optimization of machining system, machining conditions, constraints, depth of cut feed and speed.

**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, robotized tool assembly, tool management system. Tool monitoring, presetting and offsets, wear and radius compensation.

**MODULE 3**

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

**Fixtures:** Definitions, General considerations, Machine considerations, Process considerations,
Product considerations, Types of fixtures, Vise fixtures, Milling fixtures, Boring fixtures,
Broaching fixtures, Lathe fixtures, Grinding fixtures.

**MODULE 4**

**Fixtures for Automation:** Work holders for CNC, Fixturing in FMS: Part holding on Pallets, standard fixtures, pallet changers, pallet pool, flexible fixturing – principles and methodologies, modular fixturing system: Tslot based, dowel pin based, fixturing components, computer aided fixture design – locating and clampi ng, use of GT in fixture design, fixture database.

**MODULE 5**

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

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- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXTBOOKS:**


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


**REFERENCE BOOK**


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

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| 13 | 16MAR14 | Group-6 | AUTOMATION IN MANUFACTURING SYSTEMS |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**Fundamentals of manufacturing:** fundamentals of manufacturing; Production System Facilities, Manufacturing support systems, Different types of manufacturing systems, Automation in Production Systems, Automation Principles & Strategies, Manufacturing Operations, Product, Production Relationships.

**Mathematical concepts and models:** Production concepts and mathematical models cost of manufacturing operation, numerical.

**Automation and modeling automated manufacturing systems:** Basic Elements of Automated System, Advanced Automation Functions, Levels of Automation, and Performance. Components of automation: sensors actuators and ADC, DAC, and input output devices

**MODULE 3**

**Industrial Control and process planning:** Industrial Control Systems, Sensors, Actuators, &other Control Systems, Discrete Control using PLC & PLC network, Manufacturing Support Systems, CAPP, Automated CAPP, Advanced Manufacturing.

**MODULE 4**

**Power Hydraulics & Pneumatics:** Concepts features & parameters governing the Selection of various components Necessary for Building the elements, Circuit Design & Analysis. Industrial Applications of Fluid power & pneumatic systems, Electro-Hydraulic Servo System, Fluid logic control

**MODULE 5**

**PLC:** Introduction, Micro PLC, Programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, Comparison & data Handling instructions, Sequencing Instructions,

**Computer Aided Planning and Control and Computer Monitoring**

Production Planning and control cost planning and control inventory management material requirements planning (MRP) shop floor control. Types of production. monitoring systems.

**Question paper pattern:**

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- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS**

1.Performance modeling of automated Manufacturing Systems - Viswanandham, PHI.
2.Fluid Power System - Goodwin, McGraw Hill Press Limited, 1976.
3.Principles & Applications - Webb, PLC McMillan 1992.

**REFERENCE BOOKS:**

1.Principles of CIM - Vajpayee, PHI.
2.Automation Production Systems & CIM - Mikell P Grover, Pearson Education, Asia
3.Fluid Power with Applications - Anthony Esposito, Prentice Hall, 1997.
4.Mechatronics - W, Bolton, Longman, Adderson Wesley.

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**PhD Coursework Courses – 2018 (Mechanical Engineering)**
**As per 2017 Regulation**

| 14 | 16MAR 421 | Group-6 | Production Planning and Control |
|---|---|---|---|
| **Exam Hours:03** | | **Exam Marks:100** | |

**MODULE 1**

**INTRODUCTION**

Objectives and benefits of planning and control-Functions of production control-Types of production job- batch and continuous-Product development and design-Marketing aspect - Functional aspects- Operational aspect-Durability and dependability aspect-aesthetic aspect. Profit consideration- Standardization, Simplification & specialization-Break even analysis. Simple numerical.

**MODULE 2**

**WORK STUDY**

Method study, basic procedure-Selection-Recording of process - Critical analysis, Development -Implementation - Micro motion and memo motion study - work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

**MODULE 3**

**PRODUCTION PLANNING :** Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning, numerical.

**MODULE 4**

**MASTER PRODUCTION SCHEDULING**

MRP and MRP-II; order control and flow control; routing, scheduling and priority dispatching; push and pull production systems, concept of JIT manufacturing system; logistics, distribution, and supply chain management;

**MODULE 5**

**INVENTORY CONTROL AND RECENT TRENDS IN PPC**

Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system - Ordering cycle system-Determination of Economic order quantity and economic lot size- ABC analysis-Recorder procedure-Introduction to computer integrated production planning systems- elements of JUST IN TIME SYSTEMS.

**Question paper pattern:**

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- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**


1. Martand Telsang, "Industrial Engineering and Production Management", First Edition,S. Chand and Company, 2000.
2. James.B.Dilworth,"Operations management – Design, Planning and Control for manufacturing and services" Mcgraw Hill International Edition1992.


**REFERENCES:**


1. Samson Eilon, "Elements of Production Planning and Control", Universal Book Corpn.1984
2. Elwood S.Buffa, and Rakesh K.Sarin, "Modern Production / b Operations Management", 8th Ed. John Wiley and Sons, 2000.
3. Kanishka Bedi, " Production and Operations management", 2 nd Edition, Oxford university press, 2007.
4. Melynk, Denzler, " Operations Management – A value driven approach" Irwin Mcgrawhill.
5. Norman Gaither, G. Frazier, " Operations Management" Thomson learning 9th edition IE, 2007
6. K.C.Jain & L.N. Aggarwal, "Production Planning Control and Industrial Management", Khanna Publishers, 1990.
7. S.N.Chary, "Theory and Problems in Production & Operations Management", Tata McGraw Hill, 1995.
8. Upendra Kachru, " Production and Operations Management – Text and cases" Excel books 1st edition 2007.