# Scheme & Syllabus
**Of**

# M.Tech in MACHINE DESIGN

(With effect from 2020-2021 Academic year)

**Outcome Based Education**
**with**
**Choice Based Credit System**

# ಪಠ್ಯಕ್ರಮ

**(ಶೈಕ್ಷಣಿಕವರ್ಷ 2020–21)**


**P.E.S. College of Engineering, Mandya - 571 401, Karnataka**

(An Autonomous Institution Affiliated to VTU, Belagavi
Grant -in- Aid Institution(Government of Karnataka), World Bank Funded College (TEQIP)
Accredited by NBA & NAAC and Approved by AICTE, New Delhi.)

## ಪಿ.ಇ.ಎಸ್. ತಾಂತ್ರಿಕಮಹಾವಿದ್ಯಾಲಯ

ಮಂಡ್ಯ–571 401, ಕರ್ನಾಟಕ
(ವಿ.ಟಿ.ಯು, ಬೆಳಗಾವಿ ಅಡಿಯಲ್ಲಿನ ಸ್ವಾಯತ್ತ ಸಂಸ್ಥೆ)

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# Preface

PES College of Engineering, Mandya, started in the year 1962, has become autonomous in the academic year 2008-09. Since, then it has been doing the academic and examination activities successfully. The college is running 6 Postgraduate programs. It consists of 4 M.Tech programs, which are affiliated to VTU. Other postgraduate programs are MBA and MCA.

India has become a Permanent Member by signing the Washington Accord. The accord was signed by the National Board of Accreditation (NBA) on behalf of India on 13th June 2014. It enables not only the mobility of our degree globally but also establishes equivalence to our degrees with that of the member nations such as Taiwan, Hong Kong, Ireland, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Turkey, Australia, Canada and Japan are among 16 signatories to the international agreement besides the US and the UK. Implementation of Outcome Based Education (OBE), has been the core issue for enabling the equivalence and of Indian degrees and their mobility across the countries.

Our Higher Educational Institution has adopted Credit Based system (CBCS) based semester Structure with OBE Scheme and grading system which provides the flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. There lies a shift in thinking, teaching and learning process moving towards students Centric from Teachers Centric Education which enhances the knowledge, skills & moral values of each student.

Choice Based Credit System (CBCS) provides the options for the students to select from the number of prescribed courses. The CBCS provides a 'cafeteria' type approach in which the students can choose electives from a wide range of courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, adopt an interdisciplinary approach for learning which enables integration of concepts, theories, techniques. These are greatly enhances the skill/employability of students.

In order to increase the Industry Institute Interaction, Internship have been added to the existing curriculum of 2020-21. Further, Research Methodology & IPR and two Self Study Courses have been introduced to enhance their Research ability and Self Learning ability respectively. Lab Components are also included in I & II Semester.

Dr. Umesh D R
Deputy Dean (Academic)
Associate Professor,
Dept. of CS & Engg

Dr. Nagarathna
Dean (Academic)
Professor
Dept. of CS & Engg

# P.E.S. College of Engineering, Mandya

## VISION

"PESCE shall be a leading institution imparting quality Engineering and Management education developing creative and socially responsible professionals

## MISSION

- Provide state of the art infrastructure, motivate the faculty to be proficient in their field of specialization and adopt best teaching-learning practices.
- Impart engineering and managerial skills through competent and committed faculty using outcome based educational curriculum.
- Inculcate professional ethics, leadership qualities and entrepreneurial skills to meet the societal needs.
- Promote research, product development and industry-institution interaction.

# Department of Computer Science and Engineering

## Vision

**The Vision of the Department of Mechanical Engineering:**

"Be a department well recognized for its ability to develop competent mechanical engineers capable of working in global environment"

## Mission

**The Mission of the Department of Mechanical Engineering is to:**

- Provide quality education by competent faculty.
- Provide adequate infrastructure and learning ambience for the development of essential technical skills.
- Inculcate a sense of higher education and research orientation.
- Foster industry interaction.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The Department of Mechanical Engineering, P E S Collage of Engineering, has formulated the following programme educational objectives for the under-graduate program in Mechanical Engineering:

The Mechanical Engineering graduates will be able to:

**PEO1:** Use the fundamentals of basic science, mathematics and mechanical engineering, to pursue their career as engineers as well as to lead and manage teams in global organizations.

**PEO2:** Pursue advanced education, research and development and engage in the process of life-long learning.

**PEO3:** Become entrepreneurs in a responsible, professional and ethical manner to serve the society.

## PROGRAM SPECIFIC OUTCOMES (PSOs)

Engineering graduates should be able to:

**PSO1:** Apply computer simulation and experimental methods in the design and development of sustainable products of mechanical systems.

**PSO2:** Utilize the knowledge of advanced manufacturing and condition monitoring techniques in industrial applications.

## PROGRAM OUTCOMES

Engineering Graduates will be able to:

- **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

- **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

## Credit pattern

**Programme: M.Tech Computer Science & Engineering**

| | | |
|---|---|---|
| **Core Courses** | I Semester | 12 credits |
| | II Semester | 12 credits |
| **Elective Course** | I Semester | 08 credits |
| | II Semester | 08 credits |
| **Technical Seminar** | III Semester | 02 credits |
| **Lab** | I Semester | 02 credits |
| | II Semester | 02 credits |
| **Internship** | III Semester | 06 credits |
| **Research Methodology and IPR** | III Semester | 04 credits |
| **Self Study Course** | III Semester | 06 credits |
| **Project work** | II Semester | 02 credits |
| **Project work** | III Semester | 04 credits |
| **Project work** | IV Semester | 18 credits |
| **Mini Project** | I Semester | 02 credits |
| **A total of 88 credits for 2 years** | | |

**P.E.S. COLLEGE OF ENGINEERING, MANDYA-571401**

Scheme of Teaching and Examination for M.Tech course in Mechanical Engineering

**(MACHINE DESIGN)**

## I Semester

| Sl. No. | Course Code | Course Title | Teaching Hours / Week | | | Examination Marks | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | Theory | Tutorial | Practical/ Field Work/ Assignment | CIE | SEE | Total | |
| 1. | P20MMDN11 | Advanced Machine Design | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 2. | P20MMDN12 | Finite Element Analysis | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 3. | P20MMDN13 | Theory of Elasticity | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 4. | P20MMDN14X | Professional Elective- I | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 5. | P20MMDN15X | Professional Elective- II | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 6. | P20MMDNL16 | Design Lab -I | -- | -- | 04 | 50 | 50 | 100 | 2 |
| 7. | P20MMDN17 | Mini Project | -- | -- | -- | 50 | 50 | 100 | 2 |
| **Total** | | | **20** | -- | **04** | **350** | **350** | **700** | **24** |

| **Professional Elective -I** | | | **Professional Elective -II** | | |
|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Sl. No.** | **Course Code** | **Course Title** |
| 1 | P20MMDN141 | Tribology and Bearing Design | 1 | P20MMDN151 | Advanced Material Technology |
| 2 | P20MMDN142 | Computer Applications in Design | 2 | P20MMDN152 | Experimental Mechanics |

## II Semester

| Sl. No. | Course Code | Course Title | Teaching Hours / Week | | | Examination Marks | | | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | Theory | Tutorial | Practical/ Field Work/ Assignment | CIE | SEE | Total | |
| 1. | P20MMDN21 | Dynamics & Mechanism Design | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 2. | P20MMDN22 | Advanced Theory of Vibrations | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 3. | P20MMDN23 | Fracture Mechanics | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 4. | P20MMDN24X | Professional Elective – III | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 5. | P20MMDN25X | Professional Elective – IV | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 6. | P20MMDN26 | Project Phase-1 | -- | -- | -- | 100 | -- | 100 | 2 |
| 7. | P20MMDNL27 | Design Lab-II | -- | -- | 04 | 50 | 50 | 100 | 2 |
| **Total** | | | **20** | -- | **04** | **400** | **300** | **700** | **24** |

| **Professional Elective -III** | | | **Professional Elective -IV** | | |
|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Sl. No.** | **Course Code** | **Course Title** |
| 1 | P20MMDN241 | Theory of Plasticity | 1 | P20MMDN251 | Metrology and Computer Aided Inspection |
| 2 | P20MMDN242 | Theory of Plates and Shells | 2 | P20MMDN252 | Additive Manufacturing |

| III Semester | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Teaching Hours / Week** | | | **Examination Marks** | | | **Credits** |
| | | | **Theory** | **Tutorial** | **Practical/ Field Work/ Assignment** | **CIE** | **SEE** | **Total** | |
| 1. | P20MHSM31 | Research Methodology &IPR (Common) | 04 | -- | -- | 50 | 50 | 100 | 4 |
| 2. | P20MMDN32 | Self-study course -I | -- | -- | -- | 100 | -- | 100 | 3 |
| 3. | P20MMDN33 | Self-study course -II | -- | -- | -- | 100 | -- | 100 | 3 |
| 4. | P20MMDN34 | Technical Seminar | -- | -- | -- | 100 | -- | 100 | 2 |
| 5. | P20MMDN35 | Project-Phase-II | -- | -- | -- | 100 | -- | 100 | 4 |
| 6. | P20MMDN36 | Internship | Completed during the intervening vacation of I and II semesters and / or II and III semesters) | | | 50 | 50 | 100 | 6 |
| **Total** | | | **04** | **--** | **--** | **500** | **100** | **600** | **22** |

| IV Semester | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **Teaching Hours / Week** | | | **Examination Marks** | | | **Credits** |
| | | | **Theory** | **Tutorial** | **Practical/ Field Work/ Assignment** | **CIE** | **SEE** | **Total** | |
| 1. | P20MMDN41 | Project Phase-III | -- | -- | -- | 100 | -- | 100 | 4 |
| 2. | P20MMDN42 | Project Thesis Evaluation | -- | -- | -- | 100 | -- | 100 | 6 |
| 3. | P20MMDN43 | Project Viva Voce | -- | -- | -- | -- | 100 | 100 | 6 |
| 4. | P20MMDN44 | Term Paper | -- | -- | -- | 100 | -- | 100 | 2 |
| **Total** | | | **--** | **--** | -- | 300 | 100 | **400** | **18** |

| Course Title: Advanced Machine Design | | | |
|---|---|---|---|
| **Course Code: P20MMDN11** | **Sem: I** | **L:T:P:4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course Objectives:** The course aims at strengthening the design capabilities of students by enhancing their understanding of fatigue failure, crack propagation and life estimation of machine elements subjected to fatigue loads.

## Course Content

### UNIT-1

**Fatigue of Materials**: 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 failure, High cycle and low cycle fatigue, macro/micro aspects of fatigue of metals, fatigue fracture surfaces and macroscopic features, fatigue mechanisms and microscopic features, strategies in fatigue design, Fatigue design models, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens. **10 Hrs**

**Self Study Component**: Differences between high cycle and low cycle fatigue

### UNIT- 2

**Stress-Life (S-N) Approach:** Introduction, S-N curves, General S-N behavior, fatigue limit under fully reversed uni-axial stressing, Mean stress effects on S-N curve, factors influencing S-N curve, stress concentration and notch sensitivity, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Fatigue from variable amplitude loading: spectrum loads and cumulative damage, damage quantification and concepts of damage fraction and accumulation, Palmgren-Miner linear damage rule, load interaction and sequence effects, cycle counting – level crossing counting, peak counting, simple range counting, Rain flow counting method, life estimation. Strengths, limitations and typical applications of S-N approach. **12 Hrs**

**Self Study Component**: Advantages of damage quantification/damage fraction and accumulation

### UNIT- 3

**Strain-Life(ε-N)approach**: Introduction, Monotonic stress-strain behavior, stress-strain relationships, Strain controlled test methods ,Cyclic stress-strain behavior, cyclic strain hardening and softening, cyclic stress-strain curve, Strain based approach(**ε-N)** to life estimation, determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach. Variable amplitude loading: life estimation under variable amplitude loading. Strengths, limitations and typical applications of strain-life approach. **10 Hrs**

**Self Study Component**: Concept of cyclic strain hardening and softening.

### UNIT- 4

**LEFM Approach:** Introduction, LEFM& EPFM concepts. Loading modes, stress intensity factor, K expressions for common cracked members, Crack tip plastic zone, plane stress and plane strain conditions, Fracture toughness, monotonic and cyclic plastic zone size, Fatigue crack growth, sigmoidal curve, constant amplitude fatigue crack growth test methods, fatigue crack growth for R = 0, Crack growth life estimation, Mean stress effects, crack closure. Crack growth under variable amplitude loading, load interaction models, wheeler model. Strengths, limitations and typical applications of LEFM approach. **10 Hrs**

**Self Study Component**: Crack growth life estimation.

## UNIT- 5

**Notches and their effects:** Introduction, concentrations and gradients of stress and strain, S-N approach for notched members, notch sensitivity and fatigue notch factor, effects of stress levels, mean stress effect, Haigh diagrams, notch strain analysis and strain-life approach, Neuber's rule, Glinka's rule, life estimation using strain-life approach, applications of fracture mechanics to crack growth at notches. **10 Hrs**

**Self Study Component**: effects of stress levels, mean stress effect.

**Text Books**


1 Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry O. Fuchs, **"Metal Fatigue in Engineering,"** John Wiley and Sons, 2nd Edition, 2001, ISBN: 9780471510598.

2 Julie A.Bannantine, **"Fundamentals of Metal Fatigue Analysis,"** Prentice Hall, 1990, ISBN: 978-0133401912.


**References**


1 Robert L. Norton, **"Machine Design,"** Pearson Education, 5th Edition, 16th September 2013, ISBN: 978-0133356717.

2 Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, 2nd Edition, 4th October 1993, ISBN: 978-0471558910.

3 Richard G Budynas and Keith J Nisbett, "Shigley's Mechanical Engineering Design," Tata McGraw-Hill publications, 10th Edition, 1st February 2014, ISBN:978-0073398204.


### Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** failure theories and machine elements based on different static failure criteria, **Describe** fatigue concepts and fatigue test methods. | II |
| CO 2 | **Describe** The S-N behavior of the machine components, **Make use of** various techniques for cycle counting and peak counting. | II,III |
| CO3 | **Define** concepts of strain life approach and **Apply** strain life approach for life estimation of machine elements. | II, V |
| CO4 | **Explain** concepts of LEFM, **Analyze** the crack growth life of machine elements. | II, IV |
| CO5 | **Describe** the influence of notches on fatigue life of machine elements and **Apply** concepts of fracture mechanics determine crack growth at notches. | II, V |

### *Course Articulation Matrix*

| Course Title and Code: Advanced Machine Design(P20MMDN11) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** failure theories and machine elements based on different static failure criteria, **Describe** fatigue concepts and fatigue test methods. | 2 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | - |
| **Describe** The S-N behavior of the machine components, **Make use of** using various techniques for cycle counting and peak counting. | 2 | 2 | 3 | 2 | - | - | - | - | - | - | - | 1 | 2 | - |
| **Define** concepts of strain life approach and **Apply** strain life approach for life estimation of machine elements. | 2 | 2 | 3 | 2 | - | - | - | - | - | - | - | 1 | 2 | - |
| **Explain** concepts of LEFM, **Analyze** the crack growth life of machine elements. | 2 | 3 | 3 | 2 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Describe** the influence of notches on fatigue life of machine elements and **Apply** concepts of fracture mechanics determine crack growth at notches. | 2 | 3 | 3 | 2 | - | - | - | - | - | - | - | 1 | 1 | - |

| Course Title: Finite Element Analysis | | | |
|---|---|---|---|
| **Course Code: P20MMDN12** | **Sem: I** | **L:T:P: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course Objectives:** The course aims at strengthening the capabilities of students to use various aspects of finite element method as a basic numerical tool for solving mechanical engineering problems.

## Course Content

### UNIT-1

**Introduction to Finite Element Method:** Introduction to FEM, Advantages and disadvantages of FEM, Applications of FEM, Boundary conditions: Essential and Non-essential boundary conditions, Basic steps in FEM, Element types, Displacement model, Convergence criteria, Different coordinate systems. Potential energy functional for 3-D elastic body. Methods of deriving finite element equations- Principle of minimum potential energy method, virtual work principle, method of weighted residuals (only description), strong and weak formulation. O**ne-Dimensional Elements-Analysis of Bars**: Introduction, potential energy functional for 1-D bar element, Admissible displacement function, Derivation of shape functions for linear and quadratic bar elements, Element equations – stiffness matrix, consistent nodal force vector due to traction and body forces for linear and quadratic bar elements by Galerkin approach, Assembly Procedure, Treatment of boundary conditions: Elimination and Penalty approach, Multi-point constraints, Initial strain (Temperature effects), Numericals on 1-D bar problems.

**12 hrs**

**Self Study Component**: Compatibility conditions and Convergence criteria.

### UNIT-2

**Two-Dimensional Elements-Analysis of Plane Elasticity Problems**: Plane stress and plain strain assumptions, Derivation of shape functions, strain- displacement matrix, stiffness matrix and load vectors for three-noded triangular element (TRIA 3) by variational principle. Lagrangian polynomial – shape functions for 9-noded quadrilateral elements. Iso parametric, subparametric and super parametric elements, Concept of Jacobian matrix: Derivation of Jacobian matrix for CST and 4-noded quadrilateral (QUAD 4) elements. **Three-Dimensional Elements:** Introduction, Finite element formulation – shape functions, strain-displacement matrix, element stiffness matrix, force terms for Four-Noded Tetrahedral Element (TET 4), shape functions for Eight-noded Hexahedral Element (HEXA- 8). **10 hrs**

**Self Study Component**: Shape functions for Eight-noded Hexahedral Element (HEXA- 8)

### UNIT-3

**Axi-symmetric Solid Elements**: Axi-symmetric formulation, Axi-symmetric Triangular Elements– Derivation of strain-displacement matrix, stiffness matrix and load vectors by potential energy approach. **Analysis of Plane Trusses**: Local and Global co-ordinate systems, element stiffness matrix, stress calculations, temperature effects. **10 hrs**

**Self Study Component**: Three Dimensional Trusses.

### UNIT- 4

**Analysis of Beams:** Derivation of Hermite shape functions for beam element, Stiffness matrix and load vector for beam element by Galerkin approach, element shear force and bending moment.

Numericals on plane trusses and beams. **Dynamic Considerations**: Formulation for point mass and distributed masses, Element mass matrices for one dimensional bar element, truss element, CST element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors for one-dimensional bars. **10 hrs**

**Self Study Component**: Euler Bernoulli beam theory, Application of Software for Finite Element Analysis.

**UNIT- 5**

**Heat Transfer**: Introduction, Equations for heat conduction and convection. Governing equation for three-dimensional bodies, boundary and initial conditions, derivation of finite element equations by Galerkin approach, Steady state heat transfer, one-dimensional heat conduction equation, one-dimensional element –Galerkin approach for heat conduction, One-dimensional heat transfer in thin fins, Measureme on 1D steady state heat transfer through composite walls and fins. **10 hrs**

**Self Study Component**: Analysis of two dimensional heat transfer using triangular elements.

**Lab exercises*:**

1. Introduction to MATLAB.
2. MATLAB code to solve axially loaded bar problems.
3. MATLAB code for the analysis of plane stress problems (plate with traction) using CST and 4-noded quadrilateral (QUAD 4) elements.
4. MATLAB code to analyze 2D plane Trusses and 3D space trusses.
5. MATLAB code for the analysis of beam bending problems.

**Evaluation of lab exercises is for 10 marks as assignment in CIE only, an average of one assignment, report submission and one test for 10 marks each.*

**Text Books**


**1** Chandrupatla T. R. and Belegundu A. D, **"Introduction to Finite Elements in Engineering,"** Pearson Hall India, 4th Edition, 19th October 2011, ISBN: 978-0132162746.

**2** Daryl L Logan, **"Finite Element Methods,"** Cengage Learning Engineering, 5th Edition, 15th April 2010, ISBN: 978-0495668251.

**3** Singiresu S. Rao, **"Finite Elements Method in Engineering,"** Butterworth-Heinemann, 5th Edition, 17th November 2010, ISBN: 9781856176613.


**References**


**1** Cook R. D., et al., **"Concepts and Application of Finite Elements Analysis,"** Wiley & Sons, 4th Edition, 2003, ISBN: 978-0471356059.

**2** David V. Hutton, **"Fundamentals of Finite Element Analysis,"** McGraw Hill Higher Education, 1st July 2003, ISBN: 978-0071122313.

**3** C S Desai and J F Abel, **"Introduction to the Finite Element Method,"** CBS Publisher, 1st Edition, 2005, ISBN: 9788123908953.

## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** the concept of finite element method, finite element discretization process and methods of deriving finite element equations and **Solve** one-dimensional structural problems. | II,III |
| CO2 | **Construct** finite element equations for two-dimensional and three-dimensional elements and **Analyze** two-dimensional plane stress and strain problems. | III,IV |
| CO3 | **Construct** finite element equations for axi-symmetric and plane truss elements and **Solve** axi-symmetric and plane truss problems. | III |
| CO4 | **Develop** finite element equations for beams and dynamic problems and **estimate** bending moment, shear force and stresses in beam and natural frequencies and mode shape of one-dimensional structural problems. | III,V |
| CO5 | **Develop** finite element equations for three-dimensional heat transfer problems and **estimate** temperature distribution and heat flow in composite walls and fins. | III,V |

## *Course Articulation Matrix*

| Course Title and Code: Finite Element Analysis (P20MMDN12) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** the concept of finite element method, finite element discretization process and methods of deriving finite element equations and **Solve** one-dimensional structural problems. | 3 | 2 | 1 | - | 2 | - | - | - | - | - | - | 1 | 1 | - |
| **Construct** finite element equations for two-dimensional and three-dimensional elements and **Analyze** two-dimensional plane stress and strain problems. | 2 | 3 | 1 | - | 2 | - | - | - | - | - | - | 1 | 2 | - |
| **Construct** finite element equations for axi-symmetric and plane truss elements and **Solve** axi-symmetric and plane truss problems. | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | 1 | 2 | - |
| **Develop** finite element equations for beams and dynamic problems and **estimate** bending moment, shear force and stresses in beam and natural frequencies and mode shape of one-dimensional structural problems. | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | 1 | 2 | - |
| **Develop** finite element equations for three-dimensional heat transfer problems and **estimate** temperature distribution and heat flow in composite walls and fins. | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | 1 | 2 | - |

| Course Title: Theory of Elasticity | | | |
|---|---|---|---|
| **Course Code: P20MMDN13** | **Sem: I** | **L:T:P:: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The course aims at enabling the students to understand the mathematical and physical principles of Elasticity, with different solution strategies while applying them to practical cases.

## Course Content

### Unit -1

**Stress Analysis:** Introduction, the general theory of elasticity, assumptions of linear elasticity, applications of linear elasticity. Body forces and surface forces, state of stress at a point, normal and shear stress components, Stress tensor, spherical and deviatoric stress tensors, 2D state of stress at a point, Cauchy's stress principle, direction cosines, stress components on an arbitrary plane, stress transformation, principal stresses in 3D, stress invariants, equilibrium equations, octahedral stresses, Numerical examples.

**Thermal stresses:** Introduction, thermo elastic stress-strain relations, equations of equilibrium, strain-displacement relations, general results. **12 hrs**

**Self Study Component:** Mohr's circle for 3-D state of stress.

### Unit-2

**Strain Analysis:** Introduction, types of strains, deformations, deformation in the neighborhood of a point, change in length of a linear element, linear components of change in length, rectangular strain components, state of strain at a point, interpretation of shear strain components, change in direction of a linear element, cubical dilation, change in angle between two line elements, principal axes of strain and principal strains, compatibility conditions.

**10 hrs**

**Self Study Component:** Plane strain in polar coordinates.

### Unit-3

**Stress–Strain Relations:** Introduction, Generalized Hooke's law in terms of engineering constants. Stress-strain relations for isotropic materials, modulus of rigidity, bulk modulus, Young's modulus and Poissons's ratio, relations between elastic constants, displacement equations of equilibrium. General case of Plane stress and Plane strain, Transformation of compatibility conditions from strain components to stress components, Saint Venant's principle, and principle of superposition, Existence and uniqueness of solution (uniqueness theorem)

Introduction to composite materials, stress-strain relations, basic cases of elastic symmetry, laminates, off-axis loading. **10 hrs**

**Self Study Component:** Hooke's law for Orthographic materials.

### Unit-4

**Energy Methods:** Introduction, Hooke's law and principle of superposition, work-absorbing component of displacement, work done by forces and elastic strain energy stored, reciprocal relation, Maxwell reciprocal theorem, generalized forces and displacements, Castigliano's theorem, strain energy due to axial force, shear force, bending moment, torque. Principle of virtual work, Kirchoff's theorem. **10 hrs**

**Self Study Component:** Begg's Deformeter.

### Unit-5

**General Equations in Cartesian Coordinates and Cylindrical Coordinates:** Introduction**,** Investigation of simple beam problems, Bending of narrow cantilever under end load, simply supported beam with uniform load by the use of polynomial functions (Airy's stress functions).

**Torsion** of circular and elliptical bars, torsion of prismatic bar.

Equations of equilibrium in cylindrical coordinates, Thick cylinder under uniform internal and / or external pressure, Stresses in composite tubes (shrink fits).

Stress concentration, plate with a circular hole. **10 hrs**

**Self Study Component:** The Prandtl Elastic-membrane (Saop-Film) analogy.

**Text Books**


1. **Advanced Mechanics of Solids**: L S Srinath McGraw Hill ,3rd Edition,2009 ISBN:9780070139886
2. **Applied Elasticity**: T.G.Sitharam. Govindraju, Interline publishing. ISBN 9788172960834


**References**


1. **Theory of Elasticity:** Timoshenko and Goodier, McGraw Hill 3rd Edition, 1970, ISBN:9780070701229
2. **Advanced Mechanics of Materials:** Arthur P Boresi and Richard J Schmidt., John Wiley and Sons; 6th Edition 2002, ISBN:9780471438816
3. **Applied Elasticity**: Wang. C. T. McGraw-Hill Inc.,1963 ISBN: 9780070681255


## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Describe** the state of stress and **Solve** principal stresses at a point in a continuous body. | II, III |
| CO2 | **Describe** state of a strain at a point and **Solve** principal strains in a continuous body. | II, III |
| CO3 | **Develop** stress and strain relations for isotropic and composite materials | III |
| CO4 | **Analyze** the elasticity problems based on concepts of energy. | IV |
| CO5 | **Analyze** bending and shear stresses and deflections induced in beams and torsional stresses in different members. **Solve** stresses in composite cylinders and stress concentration in a plate with hole. | III |

***Course Articulation Matrix***

**Course Title and Code: Theory of Elasticity (P20MMDN13)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Describe** the state of stress and **Solve** principal stresses at a point in a continuous body. | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Describe** state of a strain at a point and **Solve** principal strains in a continuous body. | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | - |
| **Develop** stress and strain relations for isotropic and composite materials | 2 | 2 | 1 | 2 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Analyze** the elasticity problems based on concepts of energy. | 2 | 2 | 1 | 2 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Analyze** bending and shear stresses and deflections induced in beams and torsional stresses in different members. **Solve** stresses in composite cylinders and stress concentration in a plate with hole. | 3 | 3 | 2 | 2 | - | - | - | - | - | - | - | 3 | 2 | - |

| Course Title: Tribology and Bearing Design | | | |
|---|---|---|---|
| **Course Code: P20MMDN141** | **Sem: I** | **L:T:P:: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course Objectives:** Tribology is the science and engineering of friction and wear between two bodies in relative motion. Knowledge of tribology is essential for a design engineer in his practice to reduce energy consumption in mechanical systems. This course provides the necessary theoretical background for the design of fluid film bearings.

## Course Content

### UNIT – 1

**Introduction:** Nature of surfaces – Analysis of surface roughness, Measurement of surface roughness, Friction – Causes, adhesion theory, abrasive theory, junction growth theory, laws of rolling friction, Wear – mechanisms, adhesive wear, abrasive wear, corrosive wear, fatigue and fretting wear, wear analysis, Lubrication and lubricants – types and properties of lubricants, lubricant additives, Newton's Law of viscous forces, effect of pressure and temperature on viscosity, viscosity index, regimes of lubrication, Numerical problems. **10 hrs**

**Self Study Component:** Selection of lubricants.

### UNIT – 2

**Fluid dynamics fundamentals**: Hagen – Poiseuille's theory, Flow through stationary parallel plates, Pressure induced and velocity induced flow, Numerical problems. **Hydrodynamic Bearings:** Concept of lightly loaded bearings, Petroff's equation, Pressure development mechanism. Reynolds' 2D equation with assumptions. Introduction to idealized slider bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity and Location of center of pressure of idealized slider bearing, Numerical problems. **12 hrs**

**Self Study Component:** Effects of side leakage.

### UNIT – 3

**Journal Bearings**: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommer field number and its significance. Comparison between lightly loaded and heavily loaded bearings, Numerical problems. **Bearing design:** Introduction, Practical considerations, Design of journal bearings. **10 hrs**

**Self Study Component:** Thin and Thick film lubrication.

### UNIT – 4

**Hydrostatic Bearings**: Types of hydrostatic Lubrication systems Expression for discharge, load carrying capacity, Flow rate, Condition for minimum power loss. Torque calculations. Numerical problems. **Elasto hydrodynamic Lubrication**: Introduction, Theoretical consideration, Grubin type solution, accurate solution, Different regimes in EHL contacts. **10 hrs**

**Self Study Component:** Hydrostatic lifts.

### UNIT – 5

**Gas Bearings**: Introduction to gas lubricated bearings. Governing differential equation for gas lubricated bearings. **Porous Bearings**: Introduction to porous bearings. Equations for porous bearings and working principle. **Magnetic Bearings**: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principle. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings. **10 hrs**

**Self Study Component:** Applications of Porous, Gas and Magnetic bearings.

**Text Books**

1 Majumdar.B.C,**"Introduction to Tribology of Bearing," S** Chand and Company,1st December 2010, ISBN: 978-8121929875.

2 E. I. Radzimovsky, **"Lubrication of Bearings: Theoretical Principles and Design,"**Oxford Press Company, 2000.ISBN: 5341437361

**References**

1 Bharath Bhushan, "Introduction to Tribology," John Wiley and Sons, 2nd Edition, 1st April 2013, ISBN: 978-1119944539.

2 Stachowiak G W, Batchelor A W, "Engineering Tribology,"Elsevier Butterworth-Heinemann, 2005, ISBN: 9780080875880.

3 Michael M. Khonsari, E. Richard Booser, "Applied Tribolgy", John Wiley and Sons, 2nd Edition, 27th May 2008, ISBN: 978-0470057117.

4 GerhandSchwetizer, HannesBleuler and Alfons Traxler, **"Active Magnetic Bearings,"** Springer-Verlag Berlin Heidelberg, 2009, ISBN: 978-3-642-00496-4.

**Course Outcomes**

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** nature of surfaces and parameters used in characterizing surface roughness, laws of friction, theories of friction and different wear mechanism | II |
| CO2 | **Describe** the pressure development mechanism in fluid film bearings and **Develop** Reynolds 2D equation. | II,III |
| CO3 | **Apply** Reynolds equation to pad and plain bearings to **estimate** pressure distribution and load carrying capacity. | III, V |
| CO4 | **Apply** Reynolds equation to hydrostatic bearings and **evaluate** load carrying capacity, frictional torque | III, V |
| CO5 | **Develop** governing differential equations for gas and porous bearings | III |

***Course Articulation Matrix***

**Course Title: Tribology and Bearing Design (P20MMDN141)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** nature of surfaces and parameters used in characterizing surface roughness, laws of friction, theories of friction and different wear mechanisms. | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Describe** the pressure development mechanism in fluid film bearings and **Develop** Reynolds 2D equation. | 2 | 2 | 3 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Apply** Reynolds equation to pad and plain bearings to **estimate** pressure distribution and load carrying capacity. | 2 | 2 | 3 | 1 | - | - | - | - | - | - | - | 1 | 2 | - |
| **Apply** Reynolds equation to hydrostatic bearings and **evaluate** load carrying capacity, frictional torque. | 2 | 2 | 3 | 1 | - | - | - | - | - | - | - | 1 | 2 | - |
| **Develop** governing differential equations for gas and porous bearings | 2 | 3 | 3 | 1 | - | - | - | - | - | - | - | 1 | 1 | - |

| Course Title: Computer Applications in Design | | | |
|---|---|---|---|
| **Course Code: P20MMDN142** | **Sem: I** | **L:T:P:: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The course aims at producing designers and manufacturing professionals with expertise in application of state of the art knowledge in modeling for computer assisted design.

## Course Content

### UNIT -1

**Introduction:** Definitions, Design Process, Product Cycle, Computer Aided Design (CAD)-, Hardware Integration and Networking. **Cad Software-** Data Structure, Database, Database Management System (DBMS) Database Coordinate System, Working Coordinate System, Screen Coordinate System, Modes of Graphics Operations, User Interface, Software Modules-Operating System(OS) Module, Graphics Module, Applications Module, Programming Module, Communications Module, Modeling and Viewing, Software Documentation and Development.

**Self Study Components:** Modes of Graphics Operations **10 hrs**

### UNIT – 2

**Computer Graphics:** Rasterscan Graphics, DDA Algorithm, Bresenham Algorithm, Anti-Aliasing Lines. Database Structures-Data Structure- Organisation, Data Models; Geometric Model Data, Engineering Data Management (EDM) System. **Transformations:** Translation, Scaling, Reflection or Mirror, Rotation, Concatenations, Homogeneous Transformation, 2D/3D Transformations-Translation, Scaling, Rotation about, X, Y and Z axes. Numericals. Mathematics of Projections-Orthographic and Isometric Projections. Clipping, Hidden Line or Surface removal, Color and Shading. **10 hrs**

**Self Study Components:** Database Structures-Data Structure- Organization

### UNIT- 3

**Geometric Modeling:** Requirements of Geometric Modeling, Geometric Models, Geometric Construction Methods, Constraint- Based Modeling, Other Modeling Methods- Cell Decomposition, Variant Method, Symbolic Programming, form Features; Wireframe Modeling-Definitions of Point lines, Circles, Arcs, etc. 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, Exchange of Modeling Data-IGES, STEP, Drawing Exchange Format (DXF), Dimension Measurement Interface Specification (DMIS). **11 hrs**

**Self Study Components:** Concepts of Point lines, Circles, Arcs, etc

### UNIT – 4

**Modeling Curves & Surfaces: Curve Representation**-Line, Circle, Parabola, Hyperbola, Curve Fitting- Interpolation Techniques- Legrangian Polynomial, B-Splines, Approximate Methods-Method of Least Squares, Polynomial Curve Fitting, Synthetic Curves-Hermite Cubic Spline, Bermestine Polynomials, Bezier Curve, rational Curves, and NURBS. **Surface Representation**– Analytic Surfaces, Surfaces of Revolution, Ruled Surfaces, Synthetic Surfaces- Hermite Cubic Surface, Bezier Surface, B-Spline Surface, Coons Surface Patch, Tabulated Cylinder, Sculptured Surfaces, Surfaces of Manipulation-Surface Display, Segmentation. **10 hrs**

**Self Study Components:** Curve Fitting- Interpolation Techniques

### UNIT -5

**Modeling of Solids:** Solid Representation-Concepts, Boundary Representations (B-Rep), Constructive Solid Geometry (CSG), Half Space Method, sweep representation. Organization of solid modelers. **Mechanical Assembly:** Introduction, Assembly Modeling, Parts Modeling and Representation, Hierarchical Relationships, Mating Conditions, Inference of Position from Mating Conditions, Representation Schemes, Graph Structure, Location Graph, Virtual Link, Generation of Assembling Sequences, Precedence Diagram, Liaison-Sequence Analysis, Precedence Graph, Assembly Analysis. **11 hrs**

**Self Study Components:** Generation of Assembling Sequences, Precedence Diagram

**Text books**


1 P.N. Rao, **"CAD/CAM Principles and Applications,"** McGrawHill, Education Pvt. Ltd., 3rd Edition, 2010, ISBN: 978-0070681934.

2 Ibrahim Zeid and R. Shiva subramanian, **"CAD/CAM Theory &Practice,"** Tata McGraw Hill Education Pvt. Ltd., 2nd Edition, 2010, ISBN: 978-0070151345.


**References**


1 M.P. Groover and E W Zimmers, **"CAD/CAM Computer Aided Design and Manufacture,"** Prentice Hall, 1984, ISBN: 978-0131101302.

2 C.B. Besant and E.W.K. Lui, **"Computer Aided design and Manufacture,"** Ellis Horwood Ltd., 1988, ISBN: 9780853129523.

3 Kunwoo Lee, **"Principles of CAD/CAM/CAE Systems,"**Pearson, US Edition, 1999, ISBN: 978-0201380361.


**Course Outcomes**

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** the Design Process, Product Cycle, CAD, CAD Hardware and Networks | II |
| CO2 | **Illustrate**Data Structure, Database Management System (DBMS), Coordinate Systems and Software Modules.,**Solve** 2D/3D Transformations and **Apply** the transformations to various situations | II,III |
| CO3 | **Explain** Rasterscan Graphics, Algorithm's, Database Structures and organization. **Illustrate the** Graphic Standards | II |
| CO4 | **Identify** the different types of Curves & Surfaces. **Explain the** various Representation and manipulation Techniques.- | III |
| CO5 | **Explain** techniques of Solid Modeling, **Analyze** Mechanical Assemblies | II |

***Course Articulation Matrix***

**Course Title and Code: Computer Applications in Design (P20MMDN142)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** the Design Process, Product Cycle, CAD, CAD Hardware and Networks | 2 | 2 | 1 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Illustrate** Data Structure, Database Management System (DBMS), Coordinate Systems and Software Modules. **Solve** 2D/3D Transformations and **Apply** the transformations to various situations | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | 2 | 1 | - |
| **Explain** Raster scan Graphics, Algorithm's, Database Structures and organization. **Illustrate the** Graphic Standards | 2 | 2 | 2 | - | 2 | - | - | - | - | - | - | 2 | 1 | - |
| **Identify** the different types of Curves & Surfaces. **Explain the** various Representation and manipulation Techniques | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 2 | 2 | - |
| **Explain** techniques of Solid Modeling. **Analyze** Mechanical Assemblies | 3 | 2 | 2 | - | 3 | - | - | - | - | - | - | 2 | 2 | 1 |

| Course Title: Advanced Materials Technology | | | |
|---|---|---|---|
| **Course Code: P20MMDN151** | **Sem: I** | **L:T:P:: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The aim of the course is to enable the students to understand principles and working of various processing techniques for identifying material and recommend appropriate methods to improve process performance.

## Course Content

### UNIT -1

**Structure-Property Relations & Newer Materials:** Introduction, Atomic structure, atomic bonds, secondary bonds, crystal structure, **C**rystal structure, crystal defects, grain structure, elastic and plastic deformation in single crystals, strain /work hardening, plastic deformation in polycrystalline metals, fracture of metals. **Newer Materials**: Plastics, polymerization, thermosetting and thermoplastic materials and properties. Ceramic materials and their properties. Composite materials – classification, matrix and reinforcement materials, properties, rule of mixtures, longitudinal strength and modulus (iso-strain model), transverse strength and modulus (iso-stress model), applications of composites. **11 hrs**

**Self Study Components:** Plastic deformation in polycrystalline metals, fracture of metals

### UNIT – 2

**Processing of Composites: Processing of MMCs**: Matrix and reinforcement materials, diffusion bonding, squeeze casting, reocasting, arc spray forming, superplastic forming, in situ process. **Processing of CMCs**: matrix and reinforcement materials, fabrication of glass fibers, boron fibers, carbon fibers, alumina fibers, silicon carbide fibers. Processing- slurry infiltration process, melt infiltration process, direct oxidation or Lanxide process. **Processing of PMCs**: matrix and reinforcement materials, processing of polyethylene fibers, aramid fibers. Processing of PMCs – hand layup process, spray-up technique, filament winding process, pultrusion process, autoclave moulding. **11 hrs**

**Self Study Components:** Matrix and reinforcement materials

### UNIT- 3

**Powder Metallurgy:** Introduction, Production of Powder, Characterization & Testing of Powders, Powder Conditioning, Powder Compaction, Sintering, Finishing operations, Applications of PM components. **10 hrs**

**Self Study Components:** Advantages and disadvantages of powder metallurgy.

### UNIT – 4

**Surface Treatment:** Introduction, Surface Engineering, Surface quality & integrity concepts, Mechanical treatment, Thermal spraying processes and applications, Vapour depositions processes and applications, Ion-implantation. **10 hrs**

**Self Study Components:** Advantages and disadvantages of vapour deposition process**.**

### UNIT -5

**Nano Technology:** Concept of Nanotechnology, Nanomaterials, preparation of Nanomaterials-plasma arcing, CVD, sol-gel method, electrode deposition, ball milling, New forms of carbon, types of nano-tubes, properties of ofnano-tubes, Nano material characterization –TEM, scanning probe microscopy, atomic force microscopy, scanning tunneling microscopy, applications of nanotechnology. **10 hrs**

**Self Study Components:** Methods used in SEM analysis.

**Text books**


1 E. Paul Degarmo, J.T. Black, and Ronald A Kohser. **"Materials and Processing in Manufacturing,"** John Wiley and Sons Inc., 12th Edition, 5th July 2017, ISBN: 978-1118987674.

2 K.K.Chawla, **"Composite Materials: Science & Engineering,"**Springer-Verlag, New York, 3rd Edition, 2012, ISBN: 978-0387743646.

3 A.K. Sinha. **"Powder Metallurgy,"**DhanpatRai Publications, ISBN: 978-9383182145.


**References**


1 Mich Wilson, Kamalikannangara, et. Al., **"Nano Technology: Basic Science and Emerging Technology,"** Chapman and Hall/CRC, 1st Edition, 27th June 2002, ISBN: 978-1584883395.

2 V. S. R Murthy, A. K. Jena, K. P. Gupta and G.S.Murthy, **"Structure and Properties of Engineering Materials,"** Tata McGraw Hill Education, 2003, ISBN: 9780070482876.

3 M. M. Schwartz, **"Composite Materials Hand Book,"** McGraw Hill Higher Education, ISBN: 9780070557437.

4 Rakesh Rathi, **"Nanotechnology,"** S.Chand and Company, 1st December 2010, ISBN: 978-8121930826.


## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** the concepts and principles of advanced materials and **Describing** manufacturing processes of different advanced materials. | II |
| CO2 | **Select** materials and processes for particular application. | III |
| CO3 | **Explain** the concept of powder metallurgy technique and its applications. | II |
| CO4 | **Explain** the principles and application of surface treatment methods. | II |
| CO5 | **Define** Nanotechnology**, Describe** nano material characterization. | I, II |

## *Course Articulation Matrix*

**Course Title and Code: Advanced Materials Technology(P20MMDN153)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** the concepts and principles of advanced materials and manufacturing processes | 2 | 2 | - | - | - | - | - | - | - | - | - | 1 | 1 | 1 |
| **Select** materials and processes for particular application. | 2 | 2 | - | - | - | - | 1 | - | - | - | - | 1 | 1 | 1 |
| **Explain** the concept of powder metallurgy technique. | 2 | 2 | - | - | - | - | 1 | - | - | - | - | 1 | 1 | 1 |
| **Explain** the principles and application of surface treatment methods. | 2 | 2 | - | - | 1 | - | - | - | - | - | - | 1 | - | 1 |
| **Define** Nanotechnology and **Describe** nano material characterization. | 2 | 2 | - | - | 1 | - | 1 | - | - | - | - | 2 | 1 | 2 |

| Course Title: Experimental Mechanics | | | |
|---|---|---|---|
| **Course Code: P20MMDN152** | **Sem: I** | **L:T:P:: 4:0:0** | **Cridits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE: 50; SEE: 50** | |

**Course Objective:** Experimental Stress Analysis provides the knowledge about the experimental techniques to analyze the stresses induced in the mechanical components. It also deals with the direct and indirect methods associated with the measurement of stresses. It includes the concept of brittle coatings, analysis of coating data, crack detection methods and many other photo elastic techniques.

## Course Content

### UNIT- 1

**Introduction,** Calibration standards, dimension and units, generalized measurement system, basic concept in dynamic measurement, system response, distortion impedance matching, experiment planning, **Data acquisition and processing:** general data acquisition system, signal conditioning revisited data transmission, analog to digital and digital to analog conversion, basic component(storage and display) of data acquisition system. **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. **10 hrs**

**Self study components:** Common mistakes done in data acquisition.

### UNIT-2

**Strain gauge**: Characteristics of strain gauge, LVDT, electrical strain gauge, gauge factor, temperature compensation methods, strain rosette: Two element and three element rectangular and delta rosette. Wheat stone bridge, balanced and unbalanced, balancing technique, Potentiometer circuit, sensitivity, range, calibration of potentiometer. **12 hrs**

**Self study components:** Advantages, dis advantages and applications of strain gauges

### UNIT- 3

**Two dimensional photoelasticity:** Introduction, nature of light, wave theory of light, polarization, natural double refraction, stress optic law, effect of stressed models in plane and circular polariscopes, isoclinics, isochromatics, fringe order determination, fringe sharpening, separation methods-shear difference method, numerical problems. **12 hrs**

**Self study components:** Concepts of stress optic law.

### UNIT- 4

**Coating methods**: Birefringence coating technique, reflection polariscope, sensitivity of birefringent coating separation of principal stresses. **Brittle coating**: coating technique, laws of failure of brittle coating, isostatics and isoentatics, properties of stress coat materials, crack pattern, crack detection technique, Types of brittle coating, calibration of brittle coating materials.

**Self study components:** Techniques in crack detection. **10 hrs**

### UNIT- 5

**Holography and Moire Technique: Holography**: Equation for plane waves and spherical waves, intensity, coherence, recording process, reconstruction process, Holographic interferometer. **Moire techniques**: Moiré phenomenon, fringe analysis, geometrical approach, displacement approach, advantages and applications. **08 hrs**

**Self study components:** Advantages, dis advantages and applications of Holography

**Text Books**


1 Dr.Sadhu Singh, **"Experimental Stress Analysis,"** Khanna Publishers, 1st December 2009, ISBN: 978-8174091826.

2 Dally and Riley, **"Experimental Stress Analysis, "**McGraw Hill Education, 3rd Edition, 1st March 1991, ISBN: 978-0070152182.


**References**


1 Srinath, Lingaiah, et al., **"Experimental Stress Analysis,"** Tata McGraw Hill Education, 1984, ISBN: 9780074519264.

2 M.M Froncht, **"Photoelasticity Vol I and II,"** John Wiley and Sons.

3 Kuske Albrecht and Robertson,**"Photoelastic Stress Analysis, "**John Wiley and Sons, 1st January 1974, ISBN: 978-0471511014.

4 Nakra and Chaudhary, **"Instrumentation, Measurement and Analysis,"** Tata McGraw Hills Companies, New York, 7thEdition,2006, ISBN: 978-9385880629.


**Course Outcomes**

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO 1 | **Explain** the Concept of Data acquisition, processing and **analyze** experimental data. | II,IV |
| CO2 | **Explain** Electrical Resistance Strain Gauges and Strain Rosettes circuits for strain measurements and potentiometer. | II |
| CO3 | **Apply** methods of photo elasticity and **analyze** stress strain behavior of solid bodies. | III,IV |
| CO4 | **Analyze** stress strain behavior of solid bodies using differentcoating techniques. | IV |
| CO5 | **Make use of** Holography and Moire Techniques in experimental stress analysis. | III |

***Course Articulation Matrix***

**Course Title and Code: Experimental Mechanics (P20MMDN154)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** the Concept of Data acquisition, processing and **analyze** experimental data. | 2 | 2 | 1 | 2 | - | - | - | - | - | - | - | 1 | 1 | - |
| **Explain** Electrical Resistance Strain Gauges and Strain Rosettes circuits for strain measurements and potentiometer. | 2 | 2 | 1 | 1 | - | - | - | - | - | - | - | - | 1 | 1 |
| **Apply** methods of photo elasticity and **analyze** stress strain behavior of solid bodies. | 2 | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | - |
| **Analyze** stress strain behavior of solid bodies using different coating techniques. | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | - | 1 | 1 |
| **Make use of** Holography and Moire Techniques in experimental stress analysis. | 2 | 2 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | - |

| Course Title: Design lab-I | | | |
|---|---|---|---|
| **Course Code: P20MMDNL16** | **Sem:I** | **L:T:P :: 0:0:4** | **Credits:02** |
| **Contact Period: 36 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The course aims at strengthening the domain skill capabilities of students in terms of structural and thermal analysis of machine elements using commercial FEA tools. Further, the course also enhances the ability of the students to analyze experimentally, some of the design aspects of machine elements.

## Course Content

### PART-A

**Exp-1** Static stress analysis of structural elements using ANSYS workbench

- **a)** Plate with hole subjected to plane stress
- **b)** Beams of different cross-section subjected to bending and shear

**Exp-2** Static stress analysis of structural elements using ANSYS workbench

- **a)** Buckling analysis of columns
- **b)** Torsion analysis of shafts

**Exp-3** Fatigue analysis using ANSYS workbench

- **a)** Leaf spring
- **b)** Shaft under torsion

**Exp-4** Thermal analysis using ANSYS workbench

- **a)** Heat transfer in Circular fins

**Exp-5** Structural analysis of composite laminates using ANSYS workbench

a) Rectangular plate with unidirectional fiber orientations having different cut-out

### PART-B

**Exp-6** Rotating beam bending fatigue test

**Exp-7** Polariscope experiments for stress analysis

**Exp-8** Study of pressure distribution in a Journal bearing

**Exp-9** Casting of Metal Matrix Composites

**Exp-10** Processing of Polymer composites by Hand layup method

**Text Books**


1. Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, Henry O. Fuchs, **"Metal Fatigue in Engineering,"** John Wiley and Sons, 2nd Edition, 2001, ISBN: 9780471510598.
2. Julie A.Bannantine, **"Fundamentals of Metal Fatigue Analysis,"** Prentice Hall, 1990, ISBN: 978-0133401912.

**References**


1 Robert L. Norton, **"Machine Design,"** Pearson Education, 5th Edition, 16th September 2013, ISBN: 978-0133356717.

2 Jack. A. Collins, **"Failure of Materials in Mechanical Design,"**John Wiley, 2nd Edition, 4th October 1993, ISBN: 978-0471558910.

3 Richard G Budynas and Keith J Nisbett, **"Shigley's Mechanical Engineering Design,"** Tata McGraw-Hill publications, 10th Edition, 1st February 2014, ISBN: 978-0073398204.


| **Evaluation scheme** | | | | |
|---|---|---|---|---|
| **Scheme** | | **Marks** | **Event Break up** | |
| | | | **Test** | **Record** |
| **CIE** | 50% | 50 | 20 | 30 |
| **SEE** | 50% | 50 | Seminar/viva voce | |

| **Scheme for Examination** | |
|---|---|
| One Question from Part –A | 20 Marks |
| One Question from Part –B | 20 Marks |
| Viva – Voice | 10 Marks |
| **Total** | **50 Marks** |

**Course Outcomes**

At the end of the course the students should be able to:

| **Course Outcomes** | | **Blooms Level** |
|---|---|---|
| CO1 | **Solve** Structural Engineering problems using FEA tool ANSYS Workbench | VI |
| CO2 | **Solve** Fatigue and Thermal Engineering problems using ANSYS Workbench | VI |
| CO3 | **Analyze** Structural capability of composite laminates using ANSYS Workbench | IV |
| CO4 | **Demonstrate** experimentally, stress distribution using polariscope and pressure distribution in journal bearings | II |
| CO5 | **Develop** laminates using Polymer Matrix Composites/Metal Matrix Composites | III |

***Course Articulation Matrix***

**Course Title and Code: Design lab-I (P20MMDNL16)**

| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Solve** Structural Engineering problems using FEA tool ANSYS Workbench | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 2 | 3 | 1 |
| **Solve** Fatigue and Thermal Engineering problems using ANSYS Workbench | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 2 | 3 | 1 |
| **Analyze** Structural capability of composite laminates using ANSYS Workbench | 3 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | - | - | 2 | 3 | 1 |
| **Demonstrate** experimentally, stress distribution using polariscope and pressure distribution in journal bearings | 3 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | 1 |
| **evelop** laminates using Polymer Matrix omposites/Metal Matrix Composites | 3 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | - |

| Course Title: Dynamics and Mechanism Design | | | |
|---|---|---|---|
| **Course Code: P20MMDN21** | **Sem: II** | **L:T:P : 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course Objectives:** The course aims at strengthening the capabilities of students in the analysis and synthesis of mechanisms by enhancing their understanding of kinematics and dynamics of mechanical systems.

## Course Content

### UNIT – 1

**Principles of Dynamics:** Introduction to dynamics, equations of motion, generalized coordinates, Configuration space, Constraints, Virtual work- virtual displacement, virtual work and principle of virtual work, D' Alembert's principle, generalized force. Energy and momentum- potential energy, work and kinetic energy, Kinetic energy of a system, Angular momentum, Generalized momentum. Problems on principle of virtual work, D' Alembert's principle and generalized force. **11 hrs**

**Self study:** Different Co ordinate systems

### UNIT – 2

**Lagrange's Equation:** Lagrange's equation from D'Alembert's principles, examples. Hamilton's equations- Hamilton's principle, Derivation of Hamilton's equations, examples. Gyroscopic action in machines, Euler's equation of motion, problems on gyroscopic action. **10 hrs**

**Self study:** Gyroscope applications

### UNIT – 3

**System Dynamics:** Phase Plane representation, Phase plane analysis, stability of dynamical systems-Liapunov's direct method and theorems, Routh's stability criteria. Open and closed loop systems, Proportional, Integral and Derivative control actions and their characteristics. **Geometry of Motion:** Introduction, analysis and synthesis, Mechanism terminology and definition-mechanism and machine, rigid and resistant bodies, link, kinematic pair, types of kinematic pairs, kinematic chain. Planar, Spherical and spatial mechanisms, mobility, equivalent mechanisms, unique mechanisms, Grashoff's law. **11 hrs**

**Self study:** Mechanism Terminology

### UNIT – 4

**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 and crank-rocker mechanism, Crank-rocker mechanisms with optimum transmission angle. Motion Generation: Poles and relative poles, Location of poles and relative poles.**Ana1ytical Methods of Dimensional Synthesis:** Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **10 hrs.**

**Self study:** Definition of Transmission angle

### UNIT – 5

**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. **10 hrs.**

**Self study:** Overlay method

**Text Books**

1 Joseph E. Shigley and J.J.Uicker, **"Theory of Machines and Mechanism,"** Oxford University Press, 4th Edition, 26th February 2010, ISBN: 978-0195371239.

2 K.J.Waldron and G.L.Kinzel, **"Kinematics, Dynamics and Design of Machinery"** Wiley India, 3rd Edition, May 2016, ISBN: 978-1-118-93328-2.
3 D T Greenwood, **"Classical Dynamics,"** Dover Publications Inc., New Edition, 21st October 1997, ISBN: 978-0486696904.

**References**

1 A.G.Ambekar. **"Mechanism and Machine Theory,"** Prentice Hall India Pvt. Ltd., 2011, ISBN: 9788120331341.
2 Ghosh and Mallick, **"Theory of Mechanism and Machines,"** East West Press, 2008, ISBN: 978-8185938936.
3 David H. Myszka, **"Machines and Mechanisms,"** Pearson Education, 4th Edition, 9th January 2011, ISBN: 978-0132157803.

## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Define** generalized coordinates, constraints, virtual work and D' Alembert's principle, **Solve** the generalized forces in the mechanical system and equation of motion of mechanical systems using virtual and D' Alembert's principles. | I, III |
| CO2 | **Apply** Lagrange's and Hamilton's equations, **Analyze** equation of motion of mechanical systems and effect of gyroscopic couple on Aeroplanes, naval ships and automobiles. | III, IV |
| CO3 | **Describe** phase plane analysis of dynamic systems and use of Liapunov's method and Routh's stability criteria in stability analysis of systems. **Define** mechanism terminology, predict mobility of planar mechanism. | II, I |
| CO4 | **Construct** slider crank and four bar mechanisms using graphical and **Analyze** using analytical methods. | III,IV |
| CO5 | **Construct** the four bar linkages for the number of positions. | III |

***Course Articulation Matrix***

**Course Title and Code: Dynamics and Mechanism Design (P20MMDN21)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Define** generalized coordinates, constraints, virtual work and D' Alembert's principle, **Solve** the generalized forces in the mechanical system and equation of motion of mechanical systems using virtual and D' Alembert's principles. | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | - | - |
| **Apply** Lagrange's and Hamilton's equations, **Analyze** equation of motion of mechanical systems and effect of gyroscopic couple on Aeroplanes, naval ships and automobiles. | 3 | 3 | 3 | 2 | - | - | - | - | - | - | - | 3 | 2 | - |
| **Describe** phase plane analysis of dynamic systems and use of Liapunov's method and Routh's stability criteria in stability analysis of systems. **Define** mechanism terminology, predictmobility of planar mechanism. | 3 | 2 | 3 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Construct** slider crank and four bar mechanisms using graphical and **Analyze** using analytical methods. | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Construct** four bar linkages for the number of positions. | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |

| Course Title: Advanced Theory of Vibrations | | | |
|---|---|---|---|
| **Course Code: P20MMDN22** | **Sem: II** | **L:T:P :: 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course Objectives:** The course aims at enabling the students to have a thorough understanding of the principles involved in the analysis of structural vibration and to provide a sound theoretical basis for further study.

## Course Content

### UNIT- 1

**Vibration under General Forcing Conditions:** Introduction, Response Under a General Periodic Force, Response Under a Periodic Force of Irregular Form, Response Under Nonperiodic Force, Convolution integral, Response to an impulse, Response to step input, Response to general forcing condition, Response to base excitation, Response spectrum, Numerical Problems. **12 hrs**

**Self study component:** Shock Response spectrum, Shock Isolation.

### UNIT- 2

**Multi-Degree of Freedom Systems – exact analysis:** Introduction, Free vibrations-equations of motion, Matrix equations, Influence coefficients, flexibility and stiffness coefficients, Generalized coordinates and coordinate coupling: Only static coupling-no dynamic coupling, Only dynamic coupling-no static coupling, Static and dynamic coupling, Modal analysis – Natural frequencies and mode shapes (Eigen values and Eigen vectors), Undamped free vibrations, Undamped Forced vibrations, Torsional vibrations of multi-rotor systems (undamped), Numerical problems. **10 hrs**

**Self study component:** Vibration Absorber, Vibration Damping.

### UNIT- 3

**Continuous Systems:** Introduction, Transverse Vibration of a String or Cable: free vibration of a uniform string, free vibration of a string with both ends fixed. Longitudinal Vibration of a Bar or Rod: Equation of motion and solution, Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams, Rayleigh's Method, Rayleigh-Ritz Method, Numerical Problems. **08 hrs**

**Self study component:** Rayleigh's Method, Rayleigh-Ritz Method.

### UNIT- 4

**Vibration Measurement:** Introduction, Response of single degree of freedom system to base excitation, Vibration measurement scheme, Principle of vibration pickups, Vibrometer, Accelerometer, Velometer, phase distortion, numerical problems. Transducers: Variable resistance transducers, Piezoelectric transducers, Electrodynamic transducers, Linear variable differential transformer (LVDT) transducer. Capacity pickup (condenser vibrometer), fiber optic probe, Rotary Variable Differential Transducer (RVDT). Frequency Measuring Instruments, single-reed and multi-reed instruments, numerical problems. Vibration Exciters: Mechanical exciters, Electrodynamic shaker.Signal Analysis: Basic principle of data acquisition system, analogue and digital systems, analogue-to-digital converter (ADC), impulse response function, frequency response function, sampling of continuous time signals, sources of vibration in rotating machines, classification of forces, common machinery faults requiring diagnosis, Spectrum analyzers, Dynamic Testing of Machines and Structures, experimental modal analysis of beams.

**10 hrs**

**Self study component:** General experimental set-up for vibration testing, Experimental modal analysis for beams.

## UNIT- 5

**Non-Linear Vibrations:** Introduction, Examples of non-linear systems – simple pendulum, vibration of a string, hard and soft spring, variable mass system, abrupt non-linearity, Phase plane, phase plane for linear system, phase plane plot and displacement time plot. Method of isoclines, phase-plane trajectories of a linear system, trajectory of a system having dry – friction damping. Undamped free vibrations with non-linear spring forces, phase plane plot for hard spring system and soft spring system. Perturbation method, Forced vibration with non-linear spring forces. **12 hrs**

**Self study component:** Self-excited oscillations, Method of Iteration

**Text Books**


1 S.S. Rao, **"Mechanical Vibrations,"** Pearson Education Inc., 5thEdition, 7th September 2011, ISBN: 978-0132128193.

2 G.K. Grover, **"Mechanical Vibrations,"**Nem Chand & Bros, 2009, ISBN: 978-8185240565.

3 **C. Sujatha, "Vibration and Acoustics: Measurement and Signal Analysis," McGraw Hill Education Pvt. Ltd., 23rd December 2009, ISBN:** 978-0071332996.


**References**


1 S. Graham Kelly, **"Mechanical Vibrations,"**Cengage Learning, 1st Edition, 1st March 2011, ISBN: 978-1439062128.

2 Austin H Church, **"Mechanical Vibrations,"**John Wiley & Sons, 2nd Edition, 1963, ISBN: 978-1114187887.


### Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Construct** mathematical models for vibrating systems subjected to generalized forcing conditions and A**nalyze** system response. | III, IV |
| CO2 | **Construct** mathematical models of multi-degree of freedom systems and **Solve** Eigen values and Eigen vectors. | III |
| CO3 | **Develop** the system response expressions for continuous systems and **Analyze** response for different boundary conditions. | III, IV |
| CO4 | **Explain** the principle of vibration measurement and signal analysis. | II |
| CO5 | **Describe** the behavior of simple non-linear systems by graphical and analytical methods. | II |

***Course Articulation Matrix***

**Course Title and Code: Advanced Theory of Vibrations (P20MMDN22)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Construct** mathematical models for vibrating systems subjected to generalized forcing conditions and A**nalyze** system response. | 2 | 3 | 3 | 1 | - | - | - | - | - | - | - | 2 | 2 | 1 |
| **Construct** mathematical models of multi-degree of freedom systems and **Solve** Eigen values and Eigen vectors. | 3 | 3 | 3 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Develop** the system response expressions for continuous systems and **Analyze** response for different boundary conditions. | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 1 | 1 | - |
| **Explain** the principle of vibration measurement and signal analysis. | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 2 | 1 | 3 |
| **Describe** the behavior of simple non-linear systems by graphical and analytical methods. | 2 | 2 | 3 | 2 | - | - | - | - | - | - | - | 2 | 1 | 1 |

| Course Title: Fractures Mechanics | | | |
|---|---|---|---|
| **Course Code: P20MMDN23** | **Sem:II** | **L:T:P : 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE: 50; SEE: 50** | |

**Course Objective:** Fracture mechanics provides methodology for prediction, prevention and control of fracture in materials, components and structures subjected to static, dynamic and sustained loads. Fracture mechanics analysis is the basis for damage tolerant design methodology. It quantifies toughness as material resistance to crack propagation.

## Course Content

### UNIT – 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. The Airy stress function, Complex stress function, Solution to crack problems, Effect of finite size, Special cases, Elliptical cracks, Numerical problems. **12 hrs**

**Self Study Component**: Historical review of fracture mechanics

### UNIT – 2

**Linear Elastic Fracture Mechanics:** 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. **10 hrs**

**Self Study Component**: Concepts of elastic zone, plastic zone and intermediate zone

### UNIT – 3

**Elastic-plastic Fracture Mechanics:** 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. **10 hrs**

**Self Study Component:** Use of J-integral. Limitation of J-integral

### UNIT – 4

**Dynamics and crack arrest:** Crack speed and kinetic energy, Dynamic stress intensity and elastic energy release rate, Crack branching, Principles of crack arrest, Fatigue pre-cracking, Instrumentation, K-R Curve, Damage Tolerant Design Methodology, Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, Mixed mode fracture and strain energy density criteria. **10 hrs**

**Self Study Component:** Fail safe and safe fail conditions in fracture mechanics

### UNIT – 5

**Computational Fracture Mechanics:** Overview of Numerical Methods, Finite Element Method, Boundary Integral Equation Method, Traditional Methods in Computational Fracture Mechanics, Stress and Displacement Matching, Elemental Crack Advance, Contour Integration, Virtual Crack Extension: Stiffness Derivative Formulation, Virtual Crack Extension: Continuum Approach, The Energy Domain Integral, Generalization to Three Dimensions, Finite Element Implementation, Mesh Design, Linear Elastic Convergence Study, Properties of Singularity Elements, Quadrilateral Element, Triangular Element. **10 hrs**

**Self Study Component:** Element discretization methods for FE analysis.

**Text Books**


1. T.L. Anderson, **"Fracture Mechanics – Fundamental and Application,"** Taylor and Francis group, CRC Press, Boca Raton, 3rd edition, 24th June, 2005, ISBN: 978-0849316562.
2. David Broek, **"Elementary Engineering Fracture Mechanics,"** Springer Publisher, 4th revised edition, 2012, ISBN: 978-8132207900.
3. **Prasanth Kumar, "Elements of Fracture Mechanics," McGraw Hill Educational Ltd, New Delhi, 1st edition, 2009, ISBN:** 978-0070656963**.**


**References**


1. R. J. Sanford, **"Principles of Fracture Mechanics,"** Prentice Hall, Pearson Education Inc., 1st edition, 8th April, 2002, ISBN: 978-0130929921.
2. S.A. Meguid, **"Engineering Fracture Mechanics,"** Elsevier Applied Science, 1st Edition, 1989, ISBN: 9781851662821.
3. Knott, **"Fundamentals of Fracture Mechanics"** Butterworth & Co Publishers Ltd., 1st October, 1973, ISBN: 978-0408705295.
4. Jayatilake, **"Fracture of Engineering Brittle Materials,"**Elsevier Applied Science Publishers, 1979, ISBN: 9780853348252.


## Course Outcomes

At the end of the course the students should be able to:

| Sl No | Course Outcomes | Blooms Level |
|---|---|---|
| 1 | **Describe** the basic fundamental understanding of the effects of crack such as defects on the performance of aerospace **Illustrate** mechanical and civil engineering structures. | II |
| 2 | **Explain** LEFM and different test methods in fracture mechanics, **Analyze** numerical and experimental methods to find stress intensity factor of mechanical components | II, IV |
| 3 | **Explain** EPFM criteria and nonlinear crack growth and **Describe** the mechanics of crack tip opening displacement | II |
| 4 | **Apply** the concepts of dynamics of crack propagation and crack arrest techniques, **Explain** the factors affecting the crack propagation and concept of fatigue crack growth law and mixed mode criteria | III, II |
| 5 | **Explain** the computational techniques to be use in fracture mechanics and **Identify** Continuum Approach, The Energy Domain Integral Mesh Design | II, III |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Fracture Mechanics (P20MMDN23)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Describe** the basic fundamental understanding of the effects of crack such as defects on the performance of aerospace **Illustrate** mechanical and civil engineering structures. | 2 | 2 | 2 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Explain** LEFM and different test methods in fracture mechanics, **Analyze** numerical and experimental methods to find stress intensity factor of mechanical components | 2 | 3 | 3 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Explain** EPFM criteria and nonlinear crack growth and **Describe** the mechanics of crack tip opening displacement | 2 | 3 | 3 | - | - | - | - | - | - | - | - | 2 | 1 | - |
| **Apply** the concepts of dynamics of crack propagation and crack arrest techniques, **Explain** the factors affecting the crack propagation and concept of fatigue crack growth law and mixed mode criteria | 3 | 2 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | - |
| **Explain** the computational techniques to be use in fracture mechanics and **Identify** Continuum Approach, The Energy Domain Integral Mesh Design | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | - |

| Course Title: Theory of Plasticity | | | |
|---|---|---|---|
| **Course Code: P20MMDN241** | **Sem: II** | **L:T:P : 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The course aims at enabling the students to understand the mathematical and physical principles of plasticity, with different solution strategies while applying them to practical cases.

## Course Content

### UNIT-1

**Introduction:** Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Representative stress. Concept of strain, Engineering and natural strains, Cubical dilation, finite strains co-efficient Octahedral strain, Strain rate and the strain rate tensor. **10 hrs**

**Self Study Component:** Concept of stress rate

### UNIT-2

**Mechanism of Plastic Deformation:** Introduction, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth. **Yield Criteria for Ductile Metals:** General considerations Von Mises and Tresca yield criterion, Yield surface for an Isotropic perfectly plastic materials, Haigh-Westergaard Stress space representation of yield criteria, Experimental verification of Yield criteria, Yield criteria for an anisotropic material. **10 hrs**

**Self Study Component:** Flow figure's or Luder's cubes

### UNIT -3

**Stress – Strain Relations:** Idealised stress-strain diagrams for different material models, Elastic stress –strain relation, Plastic stress-strain relations, Prandtl- Reuss, Saint Venant's, Levy-Von Mises equations, Plastic work and strain-Hardening hypothesis, Experimental verification of the Prandtl-Reuss equations, The plastic potential, convexity of yield locus. **10 hrs**

**Self Study Component:** Elastic strain energy functions.

### UNIT -4

**Plasticity Analysis**: Bending of beams-Introduction, analysis of stresses, shear stress distribution, and Residual stresses in plastic bending and Plastic torsion of a circular bar, residual stresses. Stresses in wire drawing, stresses in extruding cylindrical rods, 2D radial plastic flow, stresses in drawing and extruding a strip (without friction), work consumption in drawing and extruding. **12 hrs**

**Self Study Component:** Non-linear stress strain curve

### UNIT-5

**Slip Line Theory:** Introduction, Basic equations for incompressible two dimensional flows, continuity equations (Geiringer), Stresses in conditions of plain strain, convention for slip-lines, solution of plastic deformation problems, Hencky's equations, boundary conditions, Geometry of slip lines, Properties of slip lines, Construction of Slip-Line Nets. **10 hrs**

**Self Study Component:** Application of slip line field theory.

**Text books**


1. R.A.C. Slater, **"Engineering Plasticity**: **Theory and Application to Metal Forming Process,"** McMillan Press Ltd., 12th March 2011, ISBN: 9780333157091.
2. Sadhu Singh, **"Theory of Plasticity and Metal Forming Process,"** Khanna Publishers, Delhi, 3rd Edition, 2003, ISBN: 9788174090508.


**References**

1 William Johnson and Peter Bassindale Mellor, **"Plasticity for Mechanical Engineers,"** Van Nostrand Publisher, 1966.
2 Chakraborty, **"Theory of plasticity,"** Butter-Heinemann Publisher, 3rd Edition, 2nd May 2006, ISBN: 978-0750666381.
3 JacobLubliner, **"Plasticity Theory,"** Dover publications Inc. 25th April 2008, ISBN: 978-0486462905.
4 L.M. Kachnov, **"Fundamentals of the Theory of Plasticity,"** Courier Corporation, 2004, ISBN: 9780486435831.

## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Explain** the elastic behavior of solid bodies subjected to various types of loading. | II |
| CO2 | **Solve** the yielding and plastic deformation of solid metal bodies. | III |
| CO3 | **Interpret** the plastic stress-strain relations. | II |
| CO4 | **Solve** plastic deformation of beam and bar. | III |
| CO5 | **Relate** macroscopic behavior of plasticity and yielding to microscopic slip line theory | II |

***Course Articulation Matrix***

**Course Title and Code: Theory of Plasticity (P20MMDN241)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Explain** the elastic behavior of solid bodies subjected to various types of loading. | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | - |
| **Solve** the yielding and plastic deformation of solid metal bodies. | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | - |
| **Interpret** the plastic stress-strain relations. | 3 | 2 | 1 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Solve** plastic deformation of beam and bar. | 3 | 3 | 2 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |
| **Relate** macroscopic behavior of plasticity and yielding to microscopic slip line theory | 3 | 2 | 2 | 1 | - | - | - | - | - | - | - | 2 | 2 | - |

| Course Title: Theory of Plates and Shells | | | |
|---|---|---|---|
| **Course Code: P20MMDN242** | **Sem: II** | **L:T:P :: 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE: 50; SEE: 50** | |

**Course Objective:** Theory of plates and shells provides the knowledge about the bending aspects of plates, Differential analysis of loaded plates, behavior of plate material when it is fabricated into shells, different theories which explain about cylindrical shell loaded symmetrically, investigates on bending of cylindrical shells.

## Course Content

### UNIT – 1

**Introduction:** Bending of long rectangular plate into a cylindrical surface, cylindrical bending of rectangular plates, Equilibrium equation of rectangular plates, Differential equation – Bending of plated with different boundary conditions – Long plate on elastic foundation, strain energy in pure bending of plates. **10 hrs**

**Self Study Component:** Concepts of corner reactions.

### UNIT – 2

**Pure Bending:** Moment and curvature relations problems of simply supported plates-Strain energy impure bending. Numericals. **Symmetrical Bending of Circular Plates:** Basic relations in polar co-ordinates**,** Axi-symmetric circular plates, Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center, Annular circular plates, Numericals. **12 hrs**

**Self Study Component:** Strain in terms of displacement in z-direction (w)

### UNIT – 3

**Plate subjected to combined lateral and in-plane loading:** Differential equations – Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as non-central, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed\, comparison between Lavy's and Navier's solution Bending of plate under combined action of lateral and transverse loads derivation of differential equation, simply supported rectangular plate. **12 hrs**

**Self Study Component:** Expressions for vertical shear

### UNIT – 4

**Introduction to Shell Structures** – General description of various types. Classification, Membrane Theory of thin shells (Stress Analysis): Cylindrical shells –Spherical Shells- Shells of double curvature, viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. **Membrane Deformation of Shells:** Symmetrical 'loaded shell, symmetrically loaded spherical shell. **10 hrs**

**Self Study Component:** Cylindrical shells with parabolic, centenary and cycloid directrices.

### UNIT – 5

**Theories of cylindrical shells:** DKJ theory, Beam theory, Bending theory, cylindrical shell loaded symmetrically. General equation of circular cylindrical shells. Approximate investigation of bending of circular cylindrical shell. **08 hrs**

**Self Study Component:** Advantages and limitations of DKJ Theory

**Text Books**


1 Timoshenko, Woinowsky and Krieger, **"Theory of Plates and Shells"** McGraw Hill, Newyork, 2nd Revised Edition, 1st January, 1959, ISBN: 978-0070647794.

2 Ansel C Ugral, **"Stresses in Plates and Shells"**Taylor& Francis Publishers, 3rd Illustrated Revised Edition, 2009, ISBN: 9781439802700.

3 Eduard Ventsel, Theodor Krauthammer, "**Thin Plates and Shells: Theory: Analysis, and Applications"** Marcell Dekker Inc, New York,1st Edition, 24th August, 2001, ISBN: 9780824705756.

**References**

1 Wilhelm Flugge, **"Stresses in Shells,"** Springer Verlag, Berlin, ISBN: 9783662010280.
2 N K Bairagi, **"Theory of Plates,"** Khanna Publishers, New Delhi.
3 Goldnvizer, **"Theory of Elastic Thin Shells,"** Pergamon Press, New York.

## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Analyze** the bending aspects of plates, **Explain** about cylindrical shell loaded symmetrically | IV,II |
| CO2 | **Solve** Moment and curvature effects on plates in bending, **Develop** the Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center, at edges. | III |
| CO3 | **Solve s**upported plate Various loading conditions such as uniformly distributed load, hydrostatic pressure and concentrated load, **compare** Lavy's and Navier's solution , Bending of plate under combined action of lateral and transverse loads. | III, II |
| CO4 | **Define** shells and types, **Analyze** Deformation of Cylindrical shells Spherical Shells and Shells of double curvature. | I, IV |
| CO5 | **Illustrate** DKJ theory, Beam theory, Bending theory, Explain General equation of circular cylindrical shells. | II |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Theory of Plates and Shells (P20MMDN242)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Analyze** the bending aspects of plates, **Explain** about cylindrical shell loaded symmetrically | 3 | 2 | 3 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |
| **Solve** Moment and curvature effects on plates in bending, **Develop** the Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center, at edges. | 3 | 3 | 2 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |
| **Solve s**upported plate Various loading conditions such as uniformly distributed load, hydrostatic pressure and concentrated load, **compare** Lavy's and Navier's solution , Bending of plate under combined action of lateral and transverse loads. | 3 | 3 | 3 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |
| **Define** shells and types ,**Analyze** Deformation of Cylindrical shells Spherical Shells and Shells of double curvature | 2 | 2 | 3 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |
| **Illustrate** DKJ theory, Beam theory, Bending theory, **Explain** General equation of circular cylindrical shells | 2 | 3 | 2 | 1 | - | - | - | - | - | - | - | 2 | 1 | - |

| Course Title: Metrology & Computer Aided Inspection. | | | |
|---|---|---|---|
| **Course Code: P20MMDN251** | **Sem: II** | **L:T:P :: 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** This course aims at imparting the knowledge, basic concept and importance of metrology, to educate the students on different types of measurement systems. Learn about the various measuring instruments to measure the linear, angular, form and surface finish measurements. Introduce the applications of computer and laser in the field of metrology, quality control and inspection.

## Course Content

### UNIT -1

**Limits, Fits and Gauges:** Introduction, Tolerances, Interchangeability, Limits of size, Terminology, Selection of Fits, ISO System of limits and fits, Types of Gauges, Gauge Design, Problems. **Metrology of Screw Thread:** Introduction, Screw threads terminology, Effect of pitch errors, Measurement of various elements of thread, problems. **10 hrs**

**Self Study Components:** Modes of Graphics Operations

### UNIT – 2

**Measurement of Straightness, Flatness, Squareness, Parallelism, Circularity and Rotation:** Straightness, Straight edge, Test for straightness by using spirit level and autocollimator, Flatness testing, Mathematical treatment of determination of straightness and flatness of surfaces, Laser equipment for alignment testing, Parallelism, Equidistance and Coincidence, Squareness, Measurement of circularity, Tests for checking rotation, Profile measurements. **Measurement of Surface Finish:** Introduction, Surface texture and definitions, Surface roughness, Terminology as per Indian Standards, Methods of measuring surface finish- Direct instrument measurement, Replica method, The sample length or Cut-off length, Analysis of surface traces, Assessment of surface roughness as per Indian Standard, Roughness comparison specimens, Mechanical roughness indicator. **10 hrs**

**Self Study Components:** Database Structures-Data Structure- Organisation

### UNIT- 3

**Machine Tool Metrology:** Introduction, Machine tools tests, Alignment tests on lathe, Alignment tests on milling machine, Alignment tests on pillar type drilling machine, Tool wear measurement using microscope. **Co-Ordinate Measuring Machine:** Types of CMM, Probes used, Applications, Non-contact CMM using electro optical sensors for dimensional metrology, Non-contact sensors for surface finish measurements, statistical evaluation of data using computer, Data integration of CMM and data logging in computers. **12 hrs**

**Self Study Components:** Concepts of Point lines, Circles, Arcs, etc

### UNIT – 4

**Machine Vision:** Shape identification, Edge detection techniques, Normalization, gray scale color relation, Template Techniques, Surface roughness using vision system, Interfacing robot and image processing system. **Laser Applications in Metrology:** Laser interferometer, Laser inspection, Dimensional measurement techniques-Scanning Laser gauge, Photo diode array imaging, Diffraction pattern technique, Laser triangulation sensors, Two frequency laser interferometer, Laser scanning gauge and Gauging wide diameter from the diffraction pattern formed in a laser. **10 hrs**

**Self Study Components:** Curve Fitting- Interpolation Techniques**.**

## UNIT-5

**Testing and Calibration of Gauges and Dynamic Measurement:** Introduction, calibration of linear and angular measuring instruments, measurement of limit gauges, checking of slip gauges, dynamic measurement of size, form and position, automatic inspection machines, measurement during machining, electronic gauging, contactless three dimensional measurement by laser based system, multi-dimensions automatic gauging and sorting machines, electro-optical inspection, some recent developments in optical measurements. **Evaluating Uncertainty in Measurement:** Introduction, sources of uncertainty in measurements, method of evaluation of uncertainty, competence of testing and calibration laboratories, apex level calibration 2nd NPL, international traceability, mass metrology, coordinate measuring machine and uncertainty in measurements, length measurement uncertainty of CMM. **10 hrs**

**Self Study Components:** Generation of Assembling Sequences, Precedence Diagram

**Text books**


1 T G Beckwith, Roy D Marangoni and John H Lienhard, **"Mechanical Measurements,"** Pearson Prentice Hall, 2007, ISBN: 9780201847659.

2 SabrieSoloman, **"Sensors and Control systems in Manufacturing,"** McGraw Hill Book, 2nd Edition, 23rd November 2009, ISBN: 978-0071605724.

3 Donald D Eckman, **"Industrial Instrumentation,"** CBS, 1st Edition, 1st December 2004, ISBN: 978-8123908106.

4 T. Busch and R. Harlow, **"Fundamentals of Dimensional Metrology,"** Delmar Cengage Learning, 5th Edition, 21st November 2006, ISBN: 978-1418020620.

5 G. G. Thomas, **"Engineering Metrology,"** Butter Worth Publications, 1974, ISBN: 9780408705103.

6 Alan S. Morris, **"The Essence of Measurement,"** Prentice Hall of India, 1997, ISBN: 978-0133716757.

7 E. O. Doebelin, **"Measurement systems: Applications & Design,"** McGraw Hill Higher Education, 4th Education, 1st January 1990, ISBN: 978-0070173385.


**References**


1 R K Jain, **"Engineering Metrology,"** Khanna Publishers, 1st January 2009, ISBN: 978-8174091536

2 Ulrich Rembold, Armbruster and Ulzmann, **"Interface Technology for Computer Controlled Manufacturing Processes,"** CRC Press, 1st Edition, 25th January 1983, ISBN: 978-0824718367.

3 J. Watson, **"Optoelectronics,"** Van Nostrand Reinhold (UK), March 1988, ISBN: 978-0278000087.

4 Jayal A.K, **"Instrumentation and Mechanical Measurements,"**Galgotia Publications, 2000.

5 Robert G. Seippel, **"Optoelectronics for Technology and Engineering,"**Prentice Hall India, 1st October 1988, ISBN: 978-0136384045.

6 Gupta S.C, **"Engineering Metrology,"**Dhanpat rai Publications, 2005.

## Course Outcomes

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Describe** limits, fits and gauges. **Explain** metrology of screw thread. | III.II |
| CO2 | **Explain** the measurement of straightness, flatness, squareness, parallelism, circularity and rotation. **Describe** the methods of measuring surface finish. | II,III |
| CO3 | **Illustrate** various machine tool alignment tests. **Explain** co-ordinate measuring machine and data integration of CMM. | II |
| CO4 | **Explain** different types of identification and detection techniques using Machine Vision. **Describe** Laser applications in metrology. | II, III |
| CO5 | **Describe** Testing and Calibration of Gauges and Dynamic Measurement. **Explain** uncertainty in measurements and method of evaluation of uncertainty. | III,II |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Metrology & Computer Aided Inspection (P20MMDN253)** | | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Describe** limits, fits and gauges. **Explain** metrology of screw thread. | 2 | 2 | 3 | - | - | - | - | - | - | - | - | 2 | - | - |
| **Explain** the measurement of straightness, flatness, squareness, parallelism, circularity and rotation. **Describe** the methods of measuring surface finish. | 2 | 1 | 2 | - | - | - | - | - | - | - | - | 2 | - | 2 |
| **Illustrate** various machine tool alignment tests. **Explain** co-ordinate measuring machine and data integration of CMM. | 2 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 1 | 1 |
| **Explain** different types of identification and detection techniques using Machine Vision. **Describe** Laser applications in metrology. | 2 | 2 | 3 | - | - | - | - | - | - | - | - | 1 | - | 1 |
| **Describe** Testing and Calibration of Gauges and Dynamic Measurement. **Explain** uncertainty in measurements and method of evaluation of uncertainty. | 2 | 2 | 3 | - | - | - | - | - | - | - | - | 1 | - | 1 |

| Course Title: Additive Manufacturing | | | |
|---|---|---|---|
| **Course Code: P20MMDN252** | **Sem: II** | **L:T:P :: 4:0:0** | **Credits:04** |
| **Contact Period: Lecture: 52 Hr; Exam: 3 Hrs** | **Weightage: CIE:50; SEE:50** | | |

**Course Objectives:** This course exposes students to latest additive manufacturing processes used for the production of prototypes, parts and tools also about applications of AM in various fields.

## Course Content

### UNIT-I

**Introduction**: Definition of Prototype, Types of prototype, roles of prototype, history of AM systems and classification of AM systems, the eight steps in additive manufacture, advantages and disadvantages of AM process. **Liquid Based Process:** Stereo lithography Systems**:** Principle, SL resin curing process, Process parameter, process details, merits and demerits, Applications. Solid Ground Curing**:** Principle of operation, process parameters, merits and demerits, Applications. **10 Hrs**

**Self study component:** SL resin curing process.

### UNIT-II

**Powder Based Processes:** Selective Laser Sintering: Principle of operation, Powder fusion mechanism, SLS Metal and ceramic part creation, process parameters, merits and demerits, Applications. Electron Beam melting (EBM), Process, Benefits and Drawbacks, Laser Engineering Net Shaping: Principle of operation, process details, merits and demerits, applications. **Solid Based Processes:** Laminated Object Manufacturing: Principle of operation, LOM materials, process parameters, process details, merits and demerits, application. Fusion Deposition Modelling: Principle, Process parameter, Path generation, merits and demerits, Applications **10 Hrs**

**Self study component:** Electron Beam melting (EBM).

### UNIT-III

**Rapid Tooling:** Classification of Rapid tools, Soft Tooling vs. Hard Tooling. Indirect Rapid tooling: - Spray metal tooling Silicone rubber (RTV) tooling, Aluminium filled epoxy tooling, 3DKeltool process, Cast kirksite,. Direct Rapid Tooling: - Direct AIM, LOM Tools, Quick cast process, DTM RapidToo1 process: RapidSteel1.0, Rapid Steel 2.0, DMLS, Pro-Metal, Sand casting tooling, Laminate tooling. **10 Hrs**

**Self study component:** Laminate tooling

### UNIT-IV

**Concepts Modelers:** Concept modelers and its uses, difference between concept modelers and AM machine. Principle of operation, merits and demerits, Applications of Thermal jet printer, Sander's model market, 3-D printer, GenisysXs printer, JP system 5, Object Quadra systems. **Additive Manufacturing Process Optimization:** factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation**.** **11 Hrs**

**Self study component:** Influence of build orientation.

### UNIT-V

**Design for Additive Manufacturing**: Concepts and Objectives: Complex Geometry Customized Geometry, Integrated Assemblies, Elimination of Conventional Constraints. Capabilities of AM: Shape complexity, Hierarchical complexity, Functional complexity, Material complexity. **Design of build-related factors in AM:** Part Orientation, Removal of

Supports, Hollowing out Parts, Inclusion of Undercuts and other Manufacturing, Constraining Features: Interlocking, Reduction of Part Count in an Assembly, Identification Markings/Numbers. **Applications of AM**: Medical field: preparation of Medical model and applications. Automotive Industry, Aeronautical Industry, with case studies. **11 Hrs**
**Self study component:** Applications in Automotive Industry.

**Text Books**


1. Gibson, D. W. Rosen, B. Stucker "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing"Springer ISBN: 978-1-4419-1119-3 e-ISBN: 978-1-4419-1120-9
2. Pham D.T &Dimov, S.S Verlog, "Rapid Manufacturing" Springer, London 9 November 2011, ISBN-13:9781447111825
   Olaf Diegel, Axel Nordin, Damien Motte "A Practical Guide to Design for Additive Manufacturing" Springer Series in Advanced Manufacturing ISBN 978-981-13-8280-2 ISBN 978-981-13-8281-9 (eBook)


**Reference Books**


1. Paul F.Jacobs, "Stereo lithography and other RP & M Technologies" -SME, NY 1995.ISBN-13:9780872634671
   Wohlers, Terry T, "Rapid Prototyping" Wohler's Report 2000, Wohler's Association 2000. Wohlers Report 2015, 314-page publication, Wohlers Associates, Inc., April 2015


**Course Outcomes:**

After learning all the units of the course, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Classify** AM systems based on raw materials and **Explain** Liquid based systems | II |
| CO2 | **Identify** Powder based and Solid based AM systems | III |
| CO3 | **Illustrate** various types of Rapid tools processes | II |
| CO4 | **Compare** Concept modelers and AM machine, **Identify** AM Process Optimization factors. | II, III |
| CO5 | **Explain** Design factors for AM and **Summarize** applications of AM in various fields. | II |

***Course Articulation Matrix***

**Course Title and Code: Additive Manufacturing**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Classify** AM systems based on raw materials and **Explain** Liquid based systems | 2 | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - |
| **Identify** Powder based and Solid based AM systems | 2 | 2 | - | - | - | - | - | - | - | - | - | 2 | - | 1 |
| **Illustrate** various types of Rapid tools processes | 2 | 2 | - | - | - | - | - | - | - | - | - | 2 | - | 1 |
| **Compare** Concept modelers and AM machine, **Identify** AM Process Optimization factors. | 2 | 3 | - | - | - | - | - | - | - | - | - | 2 | 1 | 1 |
| **Explain** Design factors for AM and **Summarize** applications of AM in various fields. | 2 | 3 | - | - | - | - | - | - | - | - | - | 2 | 1 | 1 |

| Course Title: Project Phase -I | | | |
|---|---|---|---|
| **CourseCode: 20MMDN26** | **Sem:II** | **L:T:P :: 0:0:0** | **Credits:02** |
| | | **Weight age: CIE:100** | |

The project phase-I evaluation shall be of 100 marks CIE. It is based on the submission of report consisting Title, Introduction, Literature Survey, Objectives and Methodology (50 marks) and presentation (50 marks).

**Course Outcomes:**

After completion of Project phase-I, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO | **Identify** Title, Introduction, Literature, Objectives and Methodology. | III |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Project Phase -I** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Identify** Title, Introduction, Literature Survey and **Formulation** of Objectives and Methodology | | | | | | | | | | | | | | |

| Course Title: Design Lab II | | | |
|---|---|---|---|
| **Course Code: P20MMDNL27** | **Sem: II** | **L:T:P :: 0:0:4** | **Credits:02** |
| **Contact Period: 36 Hrs; Exam: 3 Hrs** | | **Weightage: CIE:50; SEE:50** | |

**Course objective:** The course aims at enhancing the ability of students to analyze and characterize mechanical systems subjected to various operating conditions. The course also helps the students in understanding the influence of material and geometry of the component on its structural characteristics.

## Course Content

### PART-A

**Exp-1** Modal analysis of machine elements using ANSYS workbench

**a)** Natural frequency and mode shapes of connecting rod, crank shaft.

**Exp-2** Harmonic analysis of machine elements using ANSYS workbench

**a)** Harmonic analysis of connecting rod, crank shaft.

**Exp-3** Contact stress and Bending stress analysis of Spur gear using ANSYS workbench

**Exp-4** Fluid flow analysis using ANSYS workbench

**a)** CFD analysis of Flow through Venturimeter

**b)** Mixing of fluids in Elbow Tube

**Exp-5** Explicit dynamic analysis using ANSYS workbench

**a)** Impact analysis of plate

### PART-B

**Exp-6** Modal analysis of Cantilever Beam by Impact Hammer test

**Exp-7** Harmonic analysis of Cantilever Beam and determination of damping ratio

**Exp-8**Modal analysis of Plate using FFT analyzer

**Exp-9**Wear study using pin-on-disc equipment

**Exp-10** Experiment on thrust bearing

**Exp-11** Demonstration of Additive Manufacturing part using FDM machine

| Evaluation scheme | | | | |
|---|---|---|---|---|
| **Scheme** | | **Marks** | **Event Break up** | |
| | | | **Test** | **Record** |
| **CIE** | 50% | 50 | 20 | 30 |
| **SEE** | 50% | 50 | Seminar/viva voce | |

| Scheme for Examination | |
|---|---|
| One Question from Part –A | 20 Marks |
| One Question from Part –B | 20 Marks |
| Viva – Voice | 10 Marks |
| **Total** | **50 Marks** |

**Course Outcomes:** After learning all the units of the course, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Analyze** dynamic characteristics of machine elements using ANSYS Workbench | IV |
| CO2 | **Solve** fluid flow problems using ANSYS Workbench | VI |
| CO3 | **Analyze e**xplicit dynamic behavior of components using ANSYS Workbench | IV |
| CO4 | **Demonstrate** experimentally, vibration characteristics of simple structural elements using FFT analyzer | II |
| CO5 | **Demonstrate** experimentally, the wear of materials using a pin-on-disk apparatus | II |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Design lab-II (P20MMDNL27)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Analyze** dynamic characteristics of machine elements using ANSYS Workbench | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 | 3 | 1 |
| **Solve** fluid flow problems using ANSYS Workbench | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 | 3 | 1 |
| **Analyze e**xplicit dynamic behavior of components using ANSYS Workbench | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 | 3 | 1 |
| **Demonstrate** experimentally, vibration characteristics of simple structural elements using FFT analyzer | 3 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | - |
| **Demonstrate** experimentally, the wear of materials using a pin-on-disk apparatus | 3 | 1 | 2 | - | - | - | - | - | - | - | - | 1 | 2 | - |

| SEMESTER - III | | |
|---|---|---|
| **RESEARCH METHODOLOGY AND IPR** | | |
| **Course Code : P20MHSM31** | | **CIE Marks:50** |
| **Teaching Hours/Week(L:T:P)** | **2:0:0** | **SEE Marks:50** |
| **Credits:04** | | **Exam Hours:03** |

**Unit-1**

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

**Unit-2**

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

**Unit-3**

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale. Data Collection: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

**Unit-4**

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

**Unit-5**

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection)

Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, 17 Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

**Course outcomes:**

At the end of the course the student will be able to:

- Discuss research methodology and the technique of defining a research problem

• Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.

• Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.

• Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports

• Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| **1** | Research Methodology: Methods and Techniques C.R. Kothari, Gaurav Garg New Age International 4th Edition, 2018 | C.R. Kothari, Gaurav Garg New Age International 4th Edition, 2018 | New Age International | 4th Edition, 2018 |
| **2** | Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2) | Ranjit Kumar | SAGE Publications | 3rd Edition, 2011 |
| **3** | Study Material (For the topic Intellectual Property under module 5 ) | Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, | | |
| **Reference Books** | | | | |
| **1** | Research Methods: the concise knowledge base Trochim Atomic Dog Publishing 2005 | Trochim | Atomic Dog | Publishing 2005 |
| **2** | Conducting Research Literature Reviews: From the Internet to Paper | Fink A | Sage Publications | 2009 |

| Course Articulation Matrix(CAM) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Outcomes** | **Program Outcomes(PO's)** | | | | | | | | | | | | **PSO's** | | |
| CO1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO2 | | | | | | | | | | | | | | | |
| CO3 | | | | | | | | | | | | | | | |
| CO4 | | | | | | | | | | | | | | | |
| CO5 | | | | | | | | | | | | | | | |

| Self Study Course-I | | | |
|---|---|---|---|
| **Course Title: Design and Analysis of Machine Components-I** | | | |
| **Course Code: P20MMDN32** | **Sem: III** | **L:T:P :: 0:0:0** | **Credits: 03** |
| **Exam Hrs.: 03** | | **Weightage: CIE:100** | |

**Course Objectives:** The course aims at strengthening the capabilities of students in the design, modelling and analysis of machine components by enhancing their understanding of various loads acting on machine parts and by enabling the students to use advanced CAD and FEM packages for solving structural problems.

## Course Content

### PART-A

**Design, Computer Aided Modelling and Analysis of the following machine components:**

1) Single Plate Clutch
2) Cone Clutch
3) Centrifugal Clutch Coupling
4) Screw Clamp
5) Flywheel for a Punching Machine

### PART-B

**Design, Computer Aided Modelling and Analysis of the following machine components:**

6) Piston for an I.C. Engine
7) Connecting Rod for an IC Engine
8) Crankshaft for an I.C. Engine
9) Two speed Spur Gearbox
10) Backgear Mechanism and Cone Pulley for a Lathe

**Text Books**

**1** S. N. Trikha, **"Machine Design Exercises,"** Khanna Publishers Delhi, 1st Edition, July 1997. ISBN No: 9780486696904

**References**

**1** ANSYS 15 Workbench User Manual.

| Evaluation Scheme | | | | | |
|---|---|---|---|---|---|
| **Scheme** | **Weightage** | **Marks** | **Event Break Up** | | |
| **CIE** | 100% | 100 | **Test** | **Record** | **Seminar** |
| | | | 20 | 20 | 10 |
| **SEE** | -- | -- | Questions to Set: 5 | Questions to Answer: 3 | |

| Scheme for Examination | |
|---|---|
| Two out of Three Questions from Part-A (Design Only) | 50 Marks (25 + 25) |
| One out of two Questions from Part-B (Design Only) | 50 Marks |
| **Total** | **100 Marks** |

**Course Outcomes:**

After learning all the units of the course, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Determine** the dimension of the machine components. | V |
| CO2 | **Analyze** the load and bearing strength, operational safety of the components. | IV |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Design and Analysis of Machine Components-I (P20MMDN32)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Determine** the dimension of the machine components. | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 | 3 | - |
| **Analyze** the load and bearing strength, operational safety of the components. | 3 | 3 | 3 | 2 | 3 | - | - | - | - | - | - | 2 | 3 | - |

| Self study course-II | | | |
|---|---|---|---|
| **Course Title: Industrial Sensors and Analysis Techniques** | | | |
| **Course Code: P20MMDN33** | **Sem: III** | **L:T:P :: 0:0:0** | **Credits: 03** |
| **Exam Hrs.: 03** | | **Weightage: CIE:100** | |

**Course objective:** The course enables the students to interpret physical principles applied in sensors and actuators, also to Identify different types of sensors and sensors required for specific applications.

**Course Content**

**Unit -1**

**Introduction, classification and types of sensors:** Introduction, classification of control processes, open and closed loop control systems, understanding photoelectric sensors, detection methods, proximity sensors, understanding inductive proximity sensors, understanding capacitive proximity sensors, understanding limit switches, inductive and capacitive sensors in manufacturing, understanding microwave sensing applications, understanding laser sensors. **11 hrs**

**Unit - 2**

**Networking of Sensors & Control Systems in Manufacturing:** Introduction, Number of products in a flexible system, sensor tracking the mean time between operator interventions, sensor tracking mean time of intervention, sensor tracking yield, sensors tracking the mean processing time, Network of sensors detecting machinery faults, understanding computer communications and sensors role, understanding networks in manufacturing. **11 hrs**

**Unit- 3**

**Advanced sensor technology in precision manufacturing applications:** Identification of manufactured components, digital encoder sensors, fuzzy logic for optoelectronic color sensors in manufacturing, sensors for vibration measurement of a structure, optoelectronic sensor tracking targets on a structure, sensors detecting faults in dynamic machine parts(bearings), ultrasonic stress sensor measuring dynamic changes in materials **10 hrs**

**Unit - 4**

**Industrial sensors and control**: Introduction, sensors in manufacturing, temperature sensors in process control, Pressure sensors, Fiber-optic pressure sensors, process control sensors measuring and monitoring liquid flow, control of the input/output speed of continuous web fabrication using laser Doppler velocity sensor, ultrasonic non-destructive evaluation sensor, process control sensors for acceleration. **10 hrs**

**Unit -5**

**Sensors in flexible manufacturing Systems**: Introduction, role of sensors in FMS, Robot control through vision sensors, robot guidance with vision system, End effector camera sensor for edge detection and extraction, End effector camera sensor detecting partially visible objects, ultrasonic end effector, end effector soundvision recognition sensors, End effector linear variable displacement transformer sensor, multisensor-controlled robot assembly. **10 hrs**

**Text books**


1. Sensors and control systems in manufacturing, second edition by Sabriesoloman. ISBN No: 9780071605724


**References**


1. Doebelin, E.O., Measurement systems: Application and Design, 4th ed., McGraw-Hill, New York,1990. ISBN No: 0070173389

**Course Outcomes**

At the end of the course the students should be able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO1 | **Identify** various types of sensors including thermal, mechanical, electrical, electromechanical and optical sensors | III |
| CO2 | **Explain** sensors used in detection of machinery faults | II |
| CO3 | **Describe** different sensors used in precision manufacturing applications | III |
| CO4 | **Choose** sensors for physical, chemical, and biochemical applications | III |
| CO5 | **Describe** sensors in flexible manufacturing Systems | II |

***Course Articulation Matrix***

**Course Title and Code: Industrial Sensors and Analysis Techniques (P20MMDN33)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Identify** various types of sensors including thermal, mechanical, electrical, electromechanical and optical sensors | 2 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 1 |
| **Explain** sensors used in detection of machinery faults | 2 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 1 |
| **Describe** different sensors used in precision manufacturing applications | 2 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 |
| **Choose** sensors for physical, chemical, and biochemical applications | 2 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 2 |
| **Describe** sensors in flexible manufacturing Systems | 2 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 1 |

| **Evaluation Scheme** | | | | | |
|---|---|---|---|---|---|
| **Scheme** | **Weightage** | **Marks** | **Event Break Up** | | |
| **CIE** | 100% | 100 | **Seminar I** | **Seminar II** | **Assignment** |
| | | | 40 | 40 | 10 |
| **SEE** | -- | -- | **Questions to Set:** 10 | **Questions to Answer:** 5 | |

**Scheme of SEE Question Paper (100 Marks)**

| **Duration: 3Hrs** | **Marks: 100** | **Weightage: 50%** |
|---|---|---|

- Each of the two questions set shall be so comprehensive as to cover the entire contents of the unit.
- There will be direct choice between the two questions within each unit
- Total questions to be set are 10. All carry equal marks of 20

| Course Title: Technical Seminar | | | |
|---|---|---|---|
| **Course Code: P20MMDN34** | **Sem:III** | **L:T:P :: 0:0:0** | **Credits: 04** |
| **Contact Period: Exam Hrs.: 03** | | **Weightage: CIE:100** | |

CIE marks shall be awarded by a committee comprising of HOD as Chairman, Guide /Co-Guide, in any and a senior faculty of the department. Participation in seminar by all post-graduate students of the same and other semesters of the programme shall be mandatory. The CIE marks awarded for technical seminar shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

**Course Outcomes:**

After completion of technical seminar, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO | **Identification** of topic, journals, **Discuss** about the topic selected for presentation | III, VI |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Technical Seminar(P20MMDN34)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Identification** of topic, journals, **Discuss** about the topic selected for presentation | 2 | 2 | 1 | 1 | 1 | - | - | - | 2 | 3 | - | 2 | - | - |

| Course Title: Project Phase-II | | | |
|---|---|---|---|
| **Course Code: P20MMDN35** | **Sem:III** | **L:T:P :: 0:0:0** | **Credits: 04** |
| **Exam Hrs.: 03** | | **Weightage: CIE:100** | |

The project phase-II evaluation shall be of 100 marks CIE. It is based on submission of report consisting of theoretical analysis and design approach of the work (50 marks) and presentation (50 marks).

**Course Outcomes:**

After completion of Project phase-II, the student is:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO | **Survey** the literatures and **Decide** theoretical analysis and design approach. | IV, V |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Project Phase-1I (P20MMDN35)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Survey** the literatures and **Decide** theoretical analysis and design approach. | 3 | 3 | 3 | 3 | 2 | - | - | 2 | 3 | 3 | 1 | 2 | 3 | - |

| Course Title: Internship | | | |
|---|---|---|---|
| **Course Code: P20MMDNL36** | **Sem:III** | **L:T:P :: 0:0:0** | **Credits: 06** |
| **Exam Hrs.: 03** | | **Weightage: CIE:50 SEE: 50** | |

All students have to undergo mandatory internship of 8 weeks during the vacation of I and II Semesters and / or II and III semesters. The area for internship shall be a mechanical industry/ consultancy firms related to mechanical industry (preferably design engineering related). An examination should be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be consider for the award of degree. Those, who do not take-up / complete the internship shall be declared as failed and have to complete during the subsequent examination after satisfying the internship requirements.

**Course Outcomes:**

After completion of internship, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO | **Adapt** the design knowledge in the appropriate field in manufacturing/ consultancy enterprises. | VI |

***Course Articulation Matrix***

**Course Title and Code: Internship (P20MMDNL36)**

| Course Outcomes | Program Outcomes (POs) | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Adapt** the design knowledge in the appropriate field in manufacturing/ consultancy enterprises | 3 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 2 | 3 | - |

| Course Title: Project Phase-III | | | |
|---|---|---|---|
| **Course Code: P20MMDN41** | **Sem:IV** | **L:T:P :: 0:0:0** | **Credits: 04** |
| **Exam Hrs.: 03** | | **Weightage: CIE:100** | |

The project Phase-III evaluation shall be of 100 marks CIE. It is based on the overall completion and demonstration / execution of the project (50 marks) and presentation (50 marks).

**Course Outcomes:**

After completion of Project phase-III, the student is able to:

| Course Outcomes | | Blooms Level |
|---|---|---|
| CO | **Conclude** overall project | IV |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Project Phase-III (P20MMDN41)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Conclude** overall project | 2 | 2 | 2 | 2 | 2 | - | - | 2 | 1 | - | 2 | 3 | 3 | - |

| **Course Title: Project Thesis Evaluation** | | | |
|---|---|---|---|
| **Course Code: P20MMDN42** | **Sem: IV** | **L:T:P :: 0:0:0** | **Credits: 06** |
| **Weightage: CIE:100** | | | |

The Project Phase-IV (Thesis) evaluation shall be of 100 marks CIE. It is based on the evaluation done separately by internal and external examiners and average marks of the two examiners shall be consider as final marks.

**Course Outcomes:**

After completion of Project phase-IV, the student is able to :

| **Course Outcomes** | | **Blooms Level** |
|---|---|---|
| CO | **Compile** the project work and submission of the thesis for evaluation. | VI |

| ***Course Articulation Matrix*** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Project Phase-IV (P20MMDN42)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Compile** the project work and submission of the thesis for evaluation. | 3 | 3 | 3 | 2 | 3 | 2 | - | 3 | 3 | 3 | 3 | 3 | 3 | - |

| **Course Title: Project Phase-V (Viva Voce)** | | | |
|---|---|---|---|
| **Course Code: P20MMDN43** | **Sem: IV** | **L:T:P :: 0:0:0** | **Credits: 06** |
| **Exam Hrs.: 03** | | **Weightage: SEE:100** | |

The Project Phase-V (Viva-voce) evaluation shall be of 100 marks SEE. It is based on thesis presentation and project viva-voce has to be conducted jointly by internal and external examiner for a total of 100 marks SEE.

**Course Outcomes:**

After completion of Project phase-V, the student is able to :

| **Course Outcomes** | | **Blooms Level** |
|---|---|---|
| CO | **Defend** the project work. | V |

| *Course Articulation Matrix* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Project Phase-V (P20MMDN43)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Defend** the project work. | 3 | 3 | 3 | 2 | 2 | - | - | 2 | 3 | 3 | 3 | 3 | 2 | - |

| **Course Title: Term Paper** | | | |
|---|---|---|---|
| **Course Code: P20MMDN44** | **Sem: IV** | **L:T:P :: 0:0:0** | **Credits: 02** |
| **Weightage: CIE:100** | | | |

The term paper is purely based on the project work he/ she chooses.

- The term paper shall be for 100 marks CIE only. It has to be evaluated by the committee formed by HOD consisting of PG-Coordinator, Guide and subject expert internal / external for each candidate.
- The term paper evaluation is based on the publication of an article in peer reviewed conference / journal (National / International) and quality of the journal. If the term paper is not published by the candidate or the same is communicated for publication at the end of his/her tenure, then the committee formed by HOD consisting of PG coordinator, guide and subject expert internal/ external for each candidate will assess for the award of credit.

**Course Outcomes:**

After completion of Project phase-V, the student is able to:

| **Course Outcomes** | | **Blooms Level** |
|---|---|---|
| CO | **Present** project work by submitting/publishing a technical paper in a peer reviewed conference / journal. | V |

| *Course Articulation Matrix* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Title and Code: Term Paper (P20MMDN44)** | | | | | | | | | | | | | | |
| **Course Outcomes** | **Program Outcomes (POs)** | | | | | | | | | | | | **PSOs** | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| **Resent** project work by submitting/publishing a technical paper in a peer reviewed conference / journal. | 3 | 2 | 2 | - | - | 1 | - | 3 | 3 | 3 | 2 | 3 | 3 | - |