# DAYANANDA SAGAR UNIVERSITY

Shavige Malleshwara Hills, Kumaraswamy Layout,

Bengaluru - 560111, Karnataka.

## SCHOOL OF ENGINEERING

## SCHEME & SYLLABUS
## FOR
## MASTER OF TECHNOLOGY ( M.Tech) – 2020

## MECHANICAL ENGINEERING

## SPECIALIZATION: DESIGN ENGINEERING

## (With Effect from 2020-21)

## SEMESTER I

| SL | PROGRAM CODE | COURSE CODE | COURSE TITLE | $\frac{CR}{AU}$ | SCHEME OF TEACHING | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | S/P | C |
| 1 | 204 | 20MDE5101 | APPLIED MATHEMATICS | CR | 03 | - | 02 | - | 05 |
| 2 | 204 | 20MDE5102 | FINITE ELEMENT METHOD | CR | 03 | - | 02 | - | 05 |
| 3 | 204 | 20MDE5103 | SOLID MECHANICS | CR | 03 | - | 02 | - | 05 |
| 4 | 204 | 20MDE5XXX | DEPARTMENT ELECTIVE-I | CR | 02 | - | 02 | - | 04 |
| 5 | 204 | 20MDE5XXX | DEPARTMENT ELECTIVE-II | CR | 02 | - | 02 | - | 04 |
| 6 | 204 | 20MDE5104 | SPECIAL TOPICS-1 | CR | - | - | 02 | - | 02 |
| | | | | | **13** | **-** | **12** | **-** | **25** |

## SEMESTER II

| SL | PROGRAM CODE | COURSE CODE | COURSE TITLE | $\frac{CR}{AU}$ | SCHEME OF TEACHING | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | S/P | C |
| 1 | 204 | 20MDE5201 | ADVANCED MATERIALS AND MANUFACTURING TECHNOLOGY | CR | 03 | - | 02 | - | 05 |
| 2 | 204 | 20MDE5202 | MECHANICS OF COMPOSITE MATERIALS | CR | 03 | - | 02 | - | 05 |
| 3 | 204 | 20MDE5203 | ADVANCED MACHINE DESIGN | CR | 03 | - | 02 | - | 05 |
| 4 | 204 | 20MDE5XXX | DEPARTMENT ELECTIVE-III | CR | 02 | - | 02 | - | 04 |
| 5 | 204 | 20MDE5XXX | DEPARTMENT ELECTIVE-IV | CR | 02 | - | 02 | - | 04 |
| 6 | 204 | 20MDE5204 | SPECIAL TOPICS-2 | CR | - | - | 02 | - | 02 |
| | | | | | **13** | **-** | **12** | **-** | **25** |

## SEMESTER III

| SL | PROGRAM CODE | COURSE CODE | COURSE TITLE | $\frac{CR}{AU}$ | SCHEME OF TEACHING | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | S/P | C |
| 1 | 204 | 20MDE5301 | MOOC COURSE-1** | CR | 02 | 02 | - | - | 04 |
| 2 | 204 | 20MDE5302 | DISSERTATION PHASE-1 | CR | - | - | - | 24 | 12 |
| | | | | | **02** | 02 | **-** | **12** | **16** |

## SEMESTER IV

| SL | PROGRAM CODE | COURSE CODE | COURSE TITLE | $\frac{CR}{AU}$ | SCHEME OF TEACHING | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | S/P | C |
| 1 | 204 | 20MDE5401 | MOOC COURSE-2** | CR | 02 | 02 | - | - | 04 |
| 2 | 204 | 20MDE5402 | DISSERTATION PHASE-2 | CR | - | - | - | 24 | 12 |
| | | | | | **02** | 02 | **-** | **12** | **16** |

CONTINUOUS EVALUATION: SELF-STUDY PRESENTATION/SURVEY REPORTS/QUIZ/SURPRISE TEST/ ASSIGNMENTS /PROGRAMMING EXERCISES/PRESENTATION SEMINAR & WORK SHOPS

**MOOC COURSE CAN BE CHOSEN FROM ANY INTERDISCIPLINARY OR FROM THE MECHANICAL DOMAIN.

## DEPARTMENTAL ELECTIVES – I

| SL. NO. | COURSE CODE | COURSE |
|---|---|---|
| 1 | 20MDE5031 | EXPERIMENTAL STRESS ANALYSIS |
| 2 | 20MDE5032 | KINEMATICS & DYNAMICS OF LINKAGES |
| 3 | 20MDE5033 | PRODUCT DEVELOPMENT |
| 4 | 20MDE5034 | TRIBOLOGY |
| 5 | 20MDE5035 | ROBOTICS |

## DEPARTMENTAL ELECTIVES – II

| SL. NO. | COURSE CODE | COURSE |
|---|---|---|
| 6 | 20MDE5036 | DIGITAL CONTROL SYSTEMS |
| 7 | 20MDE5037 | SENSORS AND SIGNAL CONDITIONING |
| 8 | 20MDE5038 | DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS |
| 9 | 20MDE5039 | LEAN MANUFACTURING |
| 10 | 20MDE5040 | SMART MATERIALS AND STRUCTURES |

## DEPARTMENTAL ELECTIVES – III

| SL. NO. | COURSE CODE | COURSE |
|---|---|---|
| 11 | 20MDE5041 | MECHATRONICS SYSTEM DESIGN |
| 12 | 20MDE5042 | MODELLING AND SIMULATION |
| 13 | 20MDE5043 | MECHANISM DESIGN |
| 14 | 20MDE5044 | INDUSTRIAL DESIGN AND ERGONOMICS |
| 15 | 20MDE5045 | ADDITIVE MANUFACTURING |
| 16 | 20MDE5046 | RESEARCH METHODOLOGY |

## DEPARTMENTAL ELECTIVES – IV

| SL. NO. | COURSE CODE | COURSE |
|---|---|---|
| 17 | 20MDE5047 | EMBEDDED SYSTEMS |
| 18 | 20MDE5048 | MICRO ELECTRICAL MECHANICAL SYSTEMS (MEMS) |
| 19 | 20MDE5049 | AUTOMOTIVE ELECTRONICS |
| 20 | 20MDE5050 | OPTIMIZATION TECHNIQUES |
| 21 | 20MDE5051 | RELIABILITY AND FAILURE ANALYSIS |
| 22 | 20MDE5052 | ADVANCED MECHANICAL VIBRATIONS |

**Course: APPLIED MATHEMATICS**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **APPLIED MATHEMATICS** |
| Course Code | **20MDE5101** |
| Semester | **I Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **2** | **7** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **98 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

### 2.2 Course Objectives

**Theory Component:**

- To learn the various numerical schemes for curve fitting, solving linear equations and partial differential equations.
- To study the solution to extreme problems using vibrational principle.

**Laboratory Component:**

- To learn MATLAB and Python coding for different Linear algebra, partial differential equation and curve fittings.
- To learn MATLAB and Python coding for different Analytic function, Transform method.

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Solve problems using numerical methods. | L3 |
| CO2 | Solve and use various curve fitting techniques | L3 |
| CO3 | Solve and use the fundamentals of most commonly occurring situations in the form of ODE's and PDE's for real life applications. | L3 |
| CO4 | Solve and use various Numerical linear algebra techniques. | L3 |
| CO5 | Develop the code for different analytical functions; transform method and calculus of variations using MATLAB and Python. | L5 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Calculus of Variation:** | 08 Hours |
| | Introduction, The First Variation, Euler-Lagrange equation, Isoperimetric problems. | |
| | | |
| **Unit-2** | **Curve Fitting:** | 08 Hours |
| | Linear regression, Polynomial regression, General Linear Least Squares, Newton's Divided Differences, Lagrange interpolating polynomials, Inverse interpolation, spline interpolation, and Multidimensional interpolation. | |
| | | |
| **Unit-3** | **Ordinary Differential Equations** | 10 Hours |
| | Ordinary Differential Equations: Formulations of ordinary differential equations involving Mechanical engineering problems. Solutions- Equations of first order and first degree. Equations of first order and second degree. Bernoulli equation. Euler equation. Simultaneous linear differential equations | |
| | | |
| **Unit-4** | **Numerical solution of PDE's** | 08 Hours |
| | Laplace Equation, Solution technique, Boundary conditions, the control-volume approach, Heat conduction equation, explicit methods, a simple implicit method, Crank Nicolson method, parabolic equations in two spatial domains, Case studies. | |
| | | |
| **Unit-5** | **Numerical Linear algebra:** | 08 Hours |
| | Partition method, Croute's Triangularisation method. Eigen values and Eigen vectors. Bounds on Eigen Values. Jacobi method for symmetric matrices. | |

| | | |
|---|---|---|
| | Gauss Elimination, LU decomposition, Special Matrices and Gauss Seidel, Case studies. | |
| | **Total =** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Generate a MATLAB and Python code for solving a system of linear equations using Gauss Elimination Method.<br>Generate a MATLAB and Python code for LU Decomposition (Factorization) | 8 Hours |
| Experiment 2 | Generate a MATLAB and Python code for Iterative methods to solve equations using Jacobi Iteration.<br>Generate a MATLAB and Python code for Curve fitting<br>i) Straight line fit<br>ii) Polynomial Curve fit | 6 Hours |
| Experiment 3 | Generate a MATLAB and Python code for Fourier transformation<br>i) FFT Vs DFT<br>ii) Interpolation by DFS<br>Generate a MATLAB and Python code for Euler's method differential equations<br>Generate a MATLAB and Python code for Runge – Kutta method differential equations | 6 Hours |
| Experiment 4 | Generate a MATLAB and Python code for Matrices and Eigen values<br>i) Eigen values and Eigen vectors<br>ii) Jacobi method<br>9. Generate a MATLAB and Python code for Partial Differential equations<br>i) Elliptical PDE<br>ii) Parabolic PDE<br>iii) The Crank – Nicholson method<br>iv) Two dimensional parabolic PDE | 8 Hours |
| | Open-ended Project(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

## 2.5 Text Book and References

| **Text Books:** | |
|---|---|
| 1. Chapra, S.C. and Canale, R.P. Numerical Methods for Engineers, Sixth Edition, McGraw Hill.<br>2. Bruce van Brunt, The Calculus of Variations, Springer. | |
| **Reference Books:** | |
| 1. Chapra, S.C. Applied Numerical Methods with MATLAB, Second Edition, Mc Graw-Hill.<br>2. Cheney W. and Kincaid, D. Numerical Mathematics and Computing, Sixth Edition, Brooks/Cole | |

**Course: Finite Element Method**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Finite Element Method** |
| Course Code | **20MDE5102** |
| Semester | **I Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **2** | **7** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **98 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course will equip students with the necessary knowledge to use finite element analysis to solve problems related to statics, dynamics, and heat-transfer. FEA is a design/research tool that is extensively used in industry and research institutions. Students will also gain hands-on experience in using finite element analysis software ANSYS to solve realistic engineering problems.

### 2.2 Course Objectives

The objectives of the Course are:

- Introduce the various aspects of FEM as applied to engineering problems.
- Define the element properties such as shape function and stiffness matrix for the various elements
- Formulate element properties for 1D, 2D elements
- Use of FE tool in linear structural, heat transfer, and dynamics problems
- Analyze bars and trusses
- Analyze plane elasticity problems
- Formulate and solve dynamic problems

**Laboratory Component**

- Understand and formulate the problem based on given geometry and physics
- Know how to model, analyze mechanical systems using finite element analysis software
- To impart knowledge for creating 1D/2D/3D models using preprocessing of FE software
- To impart knowledge for creating 2D/3D models using CAD software and export to finite element software
- Learn the use of commercial software to solve complex problems

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Apply the weighted residual method and Rayleigh-Ritz method to approximate the solutions of simple problems | L3 |
| CO2 | Develop finite element formulations for bar and beam elements using linear and quadratic shape functions and use them in simple heat transfer problems | L3 |
| CO3 | Formulate and use iso-parametric, axisymmetric, serendipity elements and use natural co-ordinate systems | L3 |
| CO4 | Demonstrate the applications to solid mechanics problems and dynamic considerations | L3 |
| CO5 | Model and analyze mechanical systems using ANSYS software | L5 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to the Finite Element Method** | 08 Hours |
| | Introduction, Engineering Analysis, Convergence criteria, Vibrational formulations, weighted residual methods, Potential Energy 1D Bar Element, Admissible displacement function, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain. | |
| | | |
| **Unit-2** | **One-Dimensional Elements** | 08 Hours |
| | Analysis of Bars and Trusses, Basic Equations and Potential Energy Functional, 1-D Bar Element, Assembly Procedure, Boundary and Constraint Conditions, 2-D Bar Element, 3-D Bar Element, Beam Element, Hermite shape functions, 1D Heat transfer, Truss element, Test Problems and Applications. | |
| | | |
| **Unit-3** | **Two-Dimensional Elements** | 10 Hours |
| | Analysis of Plane Elasticity Problems, Three- Noded Triangular Element (TRIA 3), Four- Noded Quadrilateral Element (QUAD 4), Axisymmetric Solid Elements: Geometric representation, Admissible displacement functions, Element stain matrix, Element stiffness matrix, Consistent nodal force vector: Body force, initial strain, Importance of higher order elements, Practical Applications. | |

| | | |
|---|---|---|
| | | |
| **Unit-4** | **Three-Dimensional Elements** | 08 Hours |
| | Applications to Solid Mechanics Problems: Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Serendipity family, Lagrange family, Shape functions for Higher Order Elements. | |
| | | |
| **Unit-5** | **Dynamic Considerations** | 08 Hours |
| | Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams. | |
| | **Total =** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 (Revision) | 1-D Elements, Bar, Truss & Beam Elements, Static & Dynamic Analysis | 04 Hours |
| Experiment 2 | Geometric Modeling of 2-D geometry using Ansys, Import 2-D geometry from other Modeling software<br>2-D Elements, Triangular & Quadrilateral, Liner and Higher-Order elements, Meshing Techniques; Manual & Automatic Meshing in Ansys, | 06 Hours |
| Experiment 3 | Geometric Modeling of 3-D geometry using Ansys, Import 3-D geometry from other Modeling software<br>3-D Elements, Tetrahedral & Hexahedral, Liner and Higher-Order elements, Meshing Techniques in 3-D; Manual & Automatic Meshing in Ansys, Import mesh from Hypermesh, | 6 Hours |
| Experiment 4 | Analysis of Structures 2-D & 3-D: Static Analysis. Modal Analysis. Harmonic Analysis. Spectrum Analysis. Buckling Analysis, Analysis of Composites. | 6 Hours |
| Additional Learning | Students are trained in 3D Modeling such as Fusion 360 & CATIA | 6 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**


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

**Reference Books:**


1. Reddy J.N., An Introduction to the Finite Element Method, McGraw - Hill International Edition, New York, 1993.
2. Bathe K. J. Finite Elements Procedures, PHI,2002.
3. Cook R. D., et al. Concepts and Application of Finite Elements Analysis, 4th Edition, Wiley & Sons, 2003.

**Course: SOLID MECHANICS**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **SOLID MECHANICS** |
| Course Code | **20MDE5103** |
| Semester | **I Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **1** | **5** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **98 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

To ascertain whether an assumption of plane stress / plane strain / axisymmetric is valid for a given state of loading

To design and analyze structures using hand calculations (wherever possible) or by using a general purpose FEA software

**2.2 Course Objectives**

The objectives of the Course are:

- To able to assess the stress/deformations for a given case of loading
- To apply the yield criteria to assess whether the material has undergone yielding
- To understand asymmetrical bending and the influence of shear Centre
- To analyze beams of different cross sections for bending
- To analyze bars of various cross sections for torsion
- To understand the procedure for axisymmetric and thermal stress analysis
- Demonstrate the ability to use commercial software to solve simple and complex structural problems.

**Laboratory Component**

The student will be able to

- To know how to model mechanical systems using finite element analysis software and analyse structural response.
- Tosimplify structural problems and analyse using finite element software such as through plane stress/plane strain/ axisymmetric assumptions.

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | To identify & analyse plane stress / plane strain / axisymmetric problems | L1/L2/L3 |
| CO2 | To analyse the principal stresses principal strain and principal planes for generalised case of loading in an isotropic material | L3 |
| CO3 | To assess the plastic deformation using different yield criterions | L2 |
| CO4 | To identify the shear centre of a beam section | L2 |
| CO5 | To analyse the structure subjecting to bending or torsion | L4 |
| CO6 | Design and analyse structures using hand calculation or using FEA | L5 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Analysis of Stress** | 08 Hours |
| | Introduction, The State of Stress at a point, Stress Components on an Arbitrary Plane, Principal Stresses, Stress Invariants, Mohr's Circles for the Three-Dimensional State of Stress, Mohr's Stress Plane, Planes of maximum shear, Octahedral Stresses, State of pure shear, Decomposition into hydrostatic and pure shear states, Cauchy's stress quadric, Lame's Ellipsoid, The plane state of stress, Differential equations of equilibrium, Equations of equilibriumfor Plane Stress State, Equations of equilibrium in cylindrical coordinates, axisymmetric stress state | |
| | | |
| **Unit-2** | **Analysis of Strain** | 06 Hours |
| | Introduction, Deformations, Change in length of a linear element, The state of strain at a point, Principal axes of strain and principal strains, Plane state of strain, Plane strain in polar coordinates, Compatibility conditions, Strain Deviator and its invariants | |
| | | |
| **Unit-3** | **Stress-strain relations for linearly elastic solids, theories of failure and introduction to ideally plastic solid, Thermal stresses** | 10 Hours |
| | Generalized statement of Hooke's law, Displacement Equations of Equilibrium, Theories of failure, Ideally Plastic Solid, Stress space and strain space – Deviatoric | |

| | | |
|---|---|---|
| | plane or $\pi$-plane, Yield Surfaces of Tresca and Von-Mises, Stress-strain relationship (Plastic flow), Prandtl-Reuss Equations<br>Thermal stresses-Thermoelastic stress strain relations, Equations of equilibrium, strain-displacement relations, general problems | |
| | | |
| **Unit-4** | **Bending of Beams** | 08 Hours |
| | Straight beams and Asymmetrical Bending, Euler-Bernoulli Hypothesis, Shear centre or centre of flexure, shear stresses in a thin-walled open sections, shear centre of T or L sections, Bending of curved Beams | |
| | | |
| **Unit-5** | **Torsion, and Axisymmetric problems** | 08 Hours |
| | Torsion of general prismatic bars (Circular/Elliptical/Equilateral Triangular/Rectangular), Membrane Analogy, Torsion of thin walled tubes, Torsion of bars with thin rectangular sections, Centre of twist and flexural centre.<br>Axisymmetric problems: Lame's problem, Stresses in composite tubes-shrink fit, Rotating discs of uniform thickness, Discs of variable thickness, Rotating shafts and cylinders | |
| | **Total =** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Identification of principal stresses and principal planes using MATLAB | 4 hours |
| Experiment 2 | Evaluation of normal stresses in straight beams as a result of thermal loading through MATLAB/FEA. | 4 hours |
| Experiment 3 | Comparison of axisymmetric analysis with Full 3D modelling using FEA. | 6 hours |
| Experiment 4 | Analysis of beams when it is subject to symmetrical / asymmetrical bending using FEA | 4 hours |
| Experiment 5 | Analysis of Torsion of bars of various cross section using FEA | 4 hours |
| Experiment 6 | Analysis a typical connecting rod or a pressure vessel using FEA | 6 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

**2.5 Text Book and References**

**Text Books:**

1. Srinath , L. S. Advanced Mechanics of Solids , Tata McGraw-Hill Education, Third Edition, 2008.
2. Kazimi, S. M. A. Solid Mechanics, Tata McGraw-Hill Education, 2001
3. Allan F. Bower, Applied Mechanics of Solids, CRC Press, 2009

**Reference Books:**

1. Shames I.H and Pitarresi, J.M.P., Introduction to Solid Mechanics, PHI Publications, Third Edition, 1999.
2. Phillips, Durelli and Tsao, Analysis of Stress and Strain, McGraw Hill Book, 1958.

**Course: Advanced Materials and Manufacturing Technology**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **Advanced Materials and Manufacturing Technology** |
| Course Code | **20MDE5201** |
| Semester | **II Semester** |

1. **Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **2** | **7** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **98 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

2. **Course Details**

**2.1 Course Aim and Summary**

The main aim of the course is to prepare the students to gain knowledge in the advanced materials and latest manufacturing process to recommend the feasibility, utilization of the materials that can be adopted in industries.The course involves new technology related to materials applications research, with focus on advanced device design, fabrication and integration, as well as new technologies based on novel materials.

**2.2 Course Objectives**

**Theory Component:**

- To study the behavior of various materials with different structure-property relationship
- To introduce the various aspects Ceramics, composites, MMCS
- To learn fabrication and operational skills and applications for Composite materials
- To have overview of surface engineering and other treatments for materials environment.

**Laboratory Component:**

- To understand the preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process.
- To comprehend the 3D printing of polymer/metal/ceramic samples.

- To design new materials using ANSYS Material Designer.
- To perform mould flow analysis
- To work on open ended problems/projects related to advanced materials.

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | **Understand** the properties of materials and its structure-property relationship | L2 |
| CO2 | **Understand** the principles underlying the functional and mechanical behaviour of ceramic materials | L2 |
| CO3 | **Develop** competency in composite manufacturing techniques, and be able to select the appropriate technique for manufacture of various composite products. | L3 |
| CO4 | **Analyse** real life surface failure problems and determine the correct surface engineering solution. | L4 |
| CO5 | **Create** a Representative Volume Elementsand compute the responses while exposing it to several macroscopic load cases. | L3 |
| CO6 | **Prepare**a new composite specimen using advanced materials. | L3 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 10 Hours |
| | Introduction- Properties of Materials, Structure property relationship, Newer Materials – Ceramics and Composite materials, Ceramics – Fine ceramics, Types of ceramics, Structure of Ceramics, Properties of Ceramics, Applications. | |
| | | |
| **Unit-2** | **Composite Materials** | 08 Hours |
| | Composite Materials- Types – Metal matrix Composites (MMC), Ceramic Matrix Composites (CMC), Polymeric composites Structure, Properties and Applications of different composite materials. | |
| | | |
| **Unit-3** | **Processing of Metal matrix Composites (MMC), Ceramic Matrix Composites (CMC)** | 08 Hours |
| | Processing of MMC & CMC, Vacuum infiltration, squeeze casting, pressure die casting, Rheo-casting, Compo-casting, Super plastic forming | |
| | | |
| **Unit-4** | **Processing of Polymer matrix Composites (PMC)** | 08 Hours |
| | Processing of PMC-Hand Lay Up, Bag Molding Process, Autoclave molding, Compression molding, Pultrusion, Filament winding, Resin Transfer molding, Injection molding. | |

| | | |
|---|---|---|
| | | |
| **Unit-5** | **Surface Engineering** | 08 Hours |
| | Surface Engineering- Surface quality & integrity, concepts, Mechanical treatment, Thermal & Thermo-chemical treatment. Thermal Spraying Processes and Applications- Vapor depositions processes and applications, Ion-treatment, Laser Treatment. | |
| | **Total** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Preparation of polymer composites through hand lay-up, vacuum bagging and resin transfer moulding process. | 7 Hours |
| Experiment 2 | Preparation of polymer/metal/ceramic samples using 3D printing. | 7 Hours |
| Experiment 3 | Designing new materials for various applications using ANSYS Material Designer. | 7 Hours |
| Experiment 4 | Mould flow analysis using ANSYS | 7 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | **Total** | **56 Hours** |

### 2.5 Text Book and References

**Text Books:**

1. Paul Degarmo, E. Black, J.T. and Ronald A Kohser, Materials and Processing in Manufacturing, John Wiley & Sons, 2011.
2. Minoru Taya, and Richard J. Arsenault, Metal Matrix Composites, Elsevier Science & Technology, 1989
3. Mallick, P.K. Fiber-Reinforced Composites: Materials, Manufacturing, and Design, Third Edition, CRC Press, 2007

**Reference Books:**

1. Schwartz, M.M. Composite Materials Handbook, Second Edition, McGraw Hill Higher Education, NewYork, 1995
2. Tadeusz Burakowski and Tadeusz Wierzchon, Surface Engineering of Metals: Principles, Equipment, Technologies, CRC Press, 1998

**Course: Mechanics of Composite Materials**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Mechanics of Composite Materials** |
| Course Code | **20MDE5202** |
| Semester | **II Semester** |

1. **Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **2** | **7** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **98 Hours** |

**Mentoring Hours:**

Class Schedule: **As per Time Table**

2. **Course Details**

**2.1 Course Aim and Summary**

- Identify the class of composite materials
- Assess the properties of the designed composite laminate based on its configuration
- Design and analyse composite configurations for structural applications

**2.2 Course Objectives**

The objectives of the course are:

- to tailor a composite to get desired characteristics (such as orthotropy/transverse isotropy/quasi-isotropy)in a composite
- to estimate the lamina properties from the constituents through micromechanical relations
- to evaluate the stresses/strains in a lamina for given case of loading
- to assess whether the lamina has undergone failure for a given state of loading
- to predict the properties of laminate based on the laminate configurations
- to predict the failure of laminate based on failure analysis of lamina
- to assess influence of temperature and humidity on the degradation of properties and failure of laminates

**Laboratory Component**

The student will be able to

- To use MATLAB to assess the properties of lamina/laminate and use it for design of composite laminates
- Implement failure models (Already available/user defined) in ANSYS to analyse composite structure.

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | To identify the class of composite materials (isotropic/orthotropy/anisotropy) based on its structure/configuration | L1 |
| CO2 | To estimate the properties of lamina from constituents | L2 |
| CO3 | To assess the failure of lamina for given loading condition | L3 |
| CO4 | To assess the laminate properties for a given stacking sequence | L2 |
| CO5 | To analyse the failure of laminate for given case of loading | L4 |
| CO6 | To design a composite configuration for any given case of loading taking into account the process/environment induced stresses etc | L5 |

**2.4 Course Content**

**Theory Component:**

| **Unit-1** | **Introduction and Micromechanics of a lamina** | 08 Hours |
|---|---|---|
| | Introduction to Composite Materials-Definition and Characteristics, Historical Development, Applications, Advantages and Limitations. Structural Performance of Conventional Materials, Geometric and Physical Definitions, Material Response under Load, types and Classifications of composite Materials, Lamina and Laminate , scales of Analysis, Basic lamina properties, Degree of Anisotropy. Micromechanical relationship for evaluation of lamina level properties from the constituents | |
| | | |
| **Unit-2** | **Module II – Macromechanics of a lamina** | 08 Hours |
| | Elastic Behavior of Composite Lamina -Stress- Strain relations, Relations between Mathematical and Engineering Constants, Stress- Strain Relations for a Thin Lamina ( 2-D), Transformation of stress and stain ( 2-D, 3-D), Transformation of Elastic Parameters ( 2-D, 3-D), Transformation of stress and strain relations in terms of Engineering Constants (2 –D), Transformation relations for Engineering Constants (2 – D). | |
| | | |

| | | |
|---|---|---|
| **Unit-3** | **Failure theories of an orthotropic lamina** | 08 Hours |
| | Strength of Composite Lamina-Introduction, Failure Theories, Maximum Stress Theory, Maximum Strain Theory, and Energy based Interaction Theory, Interactive Tensor Polynomial Theory, Failure- Mode – Based Theories, Failure Criteria for Textile Composites, Computational Procedure for Determination of Lamina Strength, Evaluation and Application of lamina Failure Theories. | |
| | | |
| **Unit-4** | **Macromechanics of laminates** | 10 Hours |
| | Laminate Terminiologies, Definitions, Elastic behavior of Multidirectional Laminates-Basic Assumptions, Strain – Displacement Relations, Stress- Strain Relations of a Layer within a laminate, Force and Moment Resultants, General Load –Deformation Relations: Laminate Stiffness, Inversion Load –Deformation Relations: Laminate Compliances, symmetric Laminates, Balance Laminates, Orthotropic Laminates, quasi- isotropic Laminates, Laminate Engineering Properties. Computational Procedure for Determination of Engineering Elastic Properties . Failure and Strength prediction of multi-directional laminates | |
| | | |
| **Unit-5** | **Hygrothermal effects on laminates** | 08 Hours |
| | Hygrothermal Effects -Introduction, Hygrothermal Effects on Mechanical Behavior, Coefficient of thermal and Moisture Expansion of a Unidirectional Lamina, Hygrothermal Strains in a Unidirectional lamina, Hygro thermo elastic Load - Deformation and Deformation – Load relations, Hygro thermal Load-Deformation relations, Co-efficient of thermal and Moisture Expansion - Multidirectional Laminates and Balanced/Symmetric laminates. Physical significance of Hygrothermal forces and Moments, Hygrothermal Isotropy and Stability. Coefficient of thermal Expansion of Unidirectional and Multidirectional carbon/ Epoxy Laminates, Hygro thermo elastic stress Analysis of Multidirectional laminates, Residual stresses. | |
| | **Total =** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Prediction of offaxis lamina strength using MATLAB | 04 Hours |
| Experiment 2 | Prediction of Laminate strength using CLT implemented in MATLAB | 08 Hours |
| Experiment 3 | Comparison of blunt notch strength of composite laminates with isotropic plate with a hole using FEA | 08 Hours |
| Experiment 4 | Composite plate subjected to plane stress conditions using FEA | 08 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**

1. Srinath , L. S. Advanced Mechanics of Solids , Tata McGraw-Hill Education, Third Edition, 2008.
2. Kazimi, S. M. A. Solid Mechanics, Tata McGraw-Hill Education, 2001
3. Allan F. Bower, Applied Mechanics of Solids, CRC Press, 2009

**Reference Books:**

1. Shames I.H and Pitarresi, J.M.P., Introduction to Solid Mechanics, PHI Publications, Third Edition, 1999.
2. Phillips, Durelli and Tsao, Analysis of Stress and Strain, McGraw Hill Book, 1958.

**Course: ADVANCED MACHINE DESIGN**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech** |
| Specialization | **Design Engineering** |
| Course Title | **Advanced Machine Design** |
| Course Code | **20MDE5203** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **3** | **-** | **2** | **7** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 42 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **98 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course will equip students with the necessary knowledge of failure prevention analysis in mechanical design, modes of mechanical failure, review of failure theories, stress-life approach, strain-life approach, LEFM approach, fatigue from variable amplitude loading &surface failure.

### 2.2 Course Objectives

The objectives of the Course are:

1. To review the theory of failures, fatigue, creep, wear of surfaces
2. Understand fatigue crack growth, stress life, and LEFM approach
3. To identify and able to solve engineering design problems
4. To know the basics of surface failure, stress, and strength

**Laboratory Component**

5. To train commercial FE software to solve fatigue and fracture problems
6. To perform fatigue & fracture failure analysis of structures and components using finite element analysis software

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Review the theory of failures, fatigue, creep, wear of surfaces | L2 |
| CO2 | Understand basic machine elements in machine design and understand their concepts in life estimation | L1 |
| CO3 | Explain LEFM concepts and S-N approach for notched members | L1 |
| CO4 | Understand the basics of surface failure, stress, and strength | L1 |
| CO5 | Demonstrate fatigue failure of mechanical components using ANSYS software | L3 |
| CO6 | Analyze fracture failure in different components using ANSYS software | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 10 Hours |
| | 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. High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods, and standard test specimens, Fatigue fracture surfaces, and macroscopic features, Fatigue mechanisms, and microscopic features. | |
| | | |
| **Unit-2** | **Stress-Life (S-N) Approach** | 08 Hours |
| | S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behavior, S-N curve representation, and approximations, Constant life diagrams, Fatigue life estimation using S-N approach. Strain-Life (ε-N) approach: Monotonic stress-strain behavior, Strain controlled test methods ,Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach. | |
| | | |
| **Unit-3** | **LEFM Approach** | 08 Hours |
| | LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis, and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches. | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **Fatigue from Variable Amplitude Loading** | 08 Hours |
| | Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction, and sequence effects, Cycle counting methods, Life estimation using stress life approach. | |
| | | |
| **Unit-5** | **Surface Failure** | 08 Hours |
| | Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. | |
| | **Total** | **42 Hours** |

**Course Content Lab Component:**

| | | |
|---|---|---|
| Experiment 1 | Fatigue analysis in ANSYS \| fatigue failure \| high cycle & low cycle fatigue life | 7 Hours |
| Experiment 2 | Fatigue Analysis of a plate with a hole using ANSYS Workbench | 7 Hours |
| Experiment 3 | Fatigue analysis of a formula SAE Hub | 7 Hours |
| Experiment 4 | fracture testing using Ansys workbench | 7 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | **Total** | **56 Hours** |

### 2.5 Text Book and References

**Text Books:**

1. Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens, and Henry O. Fuchs, Metal Fatigue in Engineering, John Wiley, New York, Second edition. 2001.
2. Jack. A. Collins, Failure of Materials in Mechanical Design, John Wiley, New York 1992.

**Reference Books:**

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

**Course: EXPERIMENTAL STRESS ANALYSIS**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **EXPERIMENTAL STRESS ANALYSIS** |
| Course Code | **20MDE5031** |
| Semester | **I Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 4 | 2 | - | 2 | 6 |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project (With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | Total | 84 Hours |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

The course will equip students with the necessary knowledge to use ESA to solve stress value problems. ESA concepts that are extensively used in industry and research institutions. Students will also gain hands-on experience in using concepts of ESA to solve realistic engineering problems.

**2.2 Course Objectives**

The objectives of the Course are:

- Introduce the various aspects of ESA as applied to engineering problems.
- To solve engineering stress related problems using ESA technique.

**Theory component**

- To study the behavior of Photo elastic materials.
- To introduce the various aspects Stress, strain and deformation calculations using fringes.
- To learn fabrication and operational skills and applications for different loading conditions of photo elastic material.

**Laboratory Component**

The student will be able to

- To know how to model, analyze and characterize the Photo elastic material using CATIA and ANSYS software.

- Learn the concepts of ESA and use their skill for getting solutions

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Mount strain gages, take measurements and analyze the obtained data | L2 |
| CO2 | Design strain gage-based transducers for measuring specific loads. | L3 |
| CO3 | Describe the different methods of photo elasticity for strain measurement viz, stress freezing, and Moirés method. | L3 |
| CO4 | Undertakeexperimentalinvestigationstoverifypredictionsbyothermethods. | L3 |
| CO5 | Apply the principles and techniques of brittle coating analysis. | L5 |
| CO6 | Apply the principles and techniques of holographic interferometry. | L5 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Analysis of Experimental Data** | 04 Hours |
| | Introduction: Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning. Analysis of different Experimental Data. | |
| | | |
| **Unit-2** | **Data Acquisition and Processing** | 06 Hours |
| | Data Acquisition and Processing: General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion. Basic components (storage and display) of data acquisition systems. Computer program as a substitute for wired logic. Force, Different torque and Strain Measurement | |
| | | |
| **Unit-3** | **Stress Analysis** | 06 Hours |
| | Stress Analysis: Two Dimensional Photo elasticity-nature of light,-wave theory of light, optical interference Polariscopes stress optic law effect of stressed model in plane and circular polariscopes, Isoclinics, Iso chromatics fringe order determination -Fringe multiplication techniques Calibration photo elastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **Three Dimensional Photoelasticity** | 06 Hours |
| | Three Dimensional Photo elasticity: Stress freezing method, General slice, Effective stresses, Stresses separation, Shear difference method, Oblique Incidence Method, secondary principal stresses, scattered light photoelasticity, Polariscope and stress data analyses. | |
| | | |
| **Unit-5** | **Coating Methods and Mini Project** | 06 Hours |
| | Coating Methods: a) Photo elastic Coating Method-Birefringence coating techniques, Sensitivity Reinforcing and thickness effects -data reduction-Stress separation techniques, Photo elastic strain gauges. b) Brittle Coatings Method: Brittle coating technique Principles data analysis-coating materials, Coating techniques.<br>**Mini Project:** Development and testing of Photoelastic material under different loading conditions and validating the results with respect to FEA Software (ANSYS/ABAQUS). | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Contact Stress Analysis of Circular Disc under diametrical compression**:** 3-D Modelling of Circular Discs with valid literature background | 04 Hours |
| Experiment 2 | Experimental results on contact stress, 2D Photo Elastic Investigation; Stress analysis in Curved beam in 2D. | 04 Hours |
| Experiment 3 | Experimental studies using Strain Gauge Instrumentation, 2D Photo elastic Investigation, Modelling and Numerical Analysis using FEM. Experimental Investigations using a Journal Bearing Test Rig. Stress Analysis of a Thick Walled Cylinder with specified Temperature at inner and outer Surfaces. | 06 Hours |
| Experiment 4 | Preparation and calibration of Photo elastic sheets. Preparation of Photo elastic models like Discs, Beams and Columns | 06 Hours |
| Experiment 5 | Stress determination for different models having regular shapes, loaded conventionally, and comparison of results with theoretical values. Measurement of strains for different shapes, by different arrangements of strain gauges. | 08 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| **Total** | | **56 Hours** |

## 2.5 Textbook and References

**Text Books:**

1. Holman,"ExperimentalMethodsforEngineers"7thEdition, Tata McGraw-Hill Companies, Inc, NewYork, 2007.
2. R.S.Sirohi,H.C.RadhaKrishna,"Mechanicalmeasurements"NewAgeInternationalPvt.Ltd.,NewDel hi,2004
3. Experimental Stress Analysis Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw-Hill, 1984.

4. Instrumentation, Measurement And Analysis Nakra Chaudhary, B C Nakra K K Chaudhry, Tata McGraw-Hill Companies, Inc, NewYork, Seventh Edition,2006.

**Reference Books:**


1. MeasurementSystemsApplicationandDesignDoeblinE.A.,4th(S.I.)Edition,McGrawHill,NewYork. 1989
2. Design and Analysis of Experiments- MontgomeryD.C.,JohnWiley&Sons,1997.
3. Experimental Stress Analysis-Dallyand Riley, McGrawHill,1991.
4. Experimental Stress Analysis-Sadhu Singh, Khanna publisher, 1990.
5. Photo elasticity ValIant Vol II-M.M.Frocht,.JohnWileyandsons,1969.
6. Strain Gauge Primer-PerryandLissner, McGrawHill,1962.

**Course: Kinematics & Dynamics of linkages**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Kinematics & Dynamics of linkages** |
| Course Code | **20MDE5032** |
| Semester | **I Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 4 | 2 | - | 2 | 6 |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| **Theory Component** | **2x14** | **28 Hours** |
| **Lab Component** | **2x14** | **28 Hours** |
| **Open-ended Project (With Industrial Collaboration based on relevance)** | **2x14** | **28 Hours** |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1CourseAim and Summary**

The course will equip students with the necessary knowledge to use dynamics to solve dynamic problems. Students will also gain hands-on experience in using concepts of dynamics of machines to solve realistic engineering problems.

**2.2 Course Objectives**

**Theory component**

The objectives of the Course are:

- Introduce the various aspects of dynamics as applied to engineering problems.
- Formulate behavior/dynamics of machines under different loading conditions.
- Use of Kinematic tools like CATIA/MATLAB/ANSYS/ABAQUS to understand the Kinematic and dynamic behavior of machines and solve vibration problems.

- To study the Principles of Design in machines.
- To introduce the various aspects Kinematics and dynamics of machines.
- To learn mechanism for simple and complicated structures using FEA

**Laboratory Component**

The student will be able to

- To know how to model, analyze mechanical systems using CATIA and ANSYS software.

- Learn the concepts of dynamics of machines and use their skill for getting solutions

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Study the basics of Kinematics and dynamics of machines | L1 |
| CO2 | Simulate the mechanism for simple and complicated structures using FEA and ADAMS | L3 |
| CO3 | Apply the tools of analytical dynamics with the main goal of developing mathematical models that describe the dynamics of systems of rigid bodies. | L3 |
| CO4 | Formulate equations of motion for complicated mechanical systems and solving these equations. | L3 |
| CO5 | Demonstrate multi body dynamics in mechanical engineering design | L3 |
| CO6 | Apply the Dynamics for conceptual design | L3 |

**2.4 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to Dynamics of Machines** | 06 Hours |
| | Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, unique mechanisms. Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method, Numerical examples. | |
| | | |
| **Unit-2** | **Principles of Dynamics** | 05 Hours |
| | Generalized Principles of Dynamics: Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, Derivation of Hamilton's equations, Numerical examples. | |
| | | |
| **Unit-3** | **Synthesis of Linkages** | 06 Hours |
| | Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. Numerical examples. | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **Dimensional Synthesis** | 05 Hours |
| | Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. | |
| | | |
| **Unit-5** | **System Dynamics** | 06 Hours |
| | System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. Numerical examples. | |
| **Total =** | | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Introduction to Multi body Dynamics Software. | 10 Hours |
| Experiment 2 | Modeling, Simulation and analysis of Four bar Mechanism, Slider-crank Mechanism and quick return mechanisms. (Kinematic, static and Dynamic Simulations and analysis) | 18 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

### 2.5 Textbook and References

**Books:**

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

**Reference Books:**

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

**Course: Product Development**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Product Development (Theory & Practice)** |
| Course Code | **20MDE5033** |
| Semester | **I Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 4 | 2 | - | 2 | 6 |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| **Theory Component** | **2x14** | **28 Hours** |
| **Lab Component** | **2x14** | **28 Hours** |
| **Open-ended Project (With Industrial Collaboration based on relevance)** | **2x14** | **28 Hours** |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

This course is intended to prepare students to design& develop products based on product principles, guidelines and skills. Students will be given experience of developing products through case studies in the lab. At the end of the module students will communicate design concepts through sketches, virtual and physical appearance model.

The course mainly focuses on Product design and development, product planning & specifications, concept generation, selection and testing, product architecture & development economics and rapid prototyping.

### 2.2 Course Objectives

**Theory Component:**

The objectives of the Course are to:

- Identify the customer needs, formulate the specifications and carry out need analysis.
- Generate, screen and test the concepts.
- Model the prototypes and carry out economic analysis
- Explain the steps involved in product development process
- Apply various methods for stimulating innovation of a product
- Synthesize design with analysis to develop new product
- Implement product principles in different organizations
- Identify the design factors and processes as per customer specifications.

- Provide a fundamental understanding of common principles, various standards & protocols

**Laboratory Component:**
The student will be able to

- Be able to explain the steps involved in product development process
- Understand the importance of product development
- Learn project and roles
- Illustrate product design concepts

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| **CO1** | Develop models by applying the concepts of product design theory | **06** |
| **CO2** | Solve problems independently and identification of customer needs for the product growth | **03** |
| **CO3** | Understand the process of product planning and specifications | **02** |
| **CO4** | Have a basic knowledge of concept generation, selection and testing | **01** |
| **CO5** | Identify the significance of product architecture and development economics | **04** |
| **CO6** | Apply embodiment principles in prototyping for small product business | **03** |
| **CO7** | Understand the product development by making a product and evaluate the salient features | **05** |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 05 Hours |
| | Product development- Characteristics of successful product development, Design and development of products, challenges of product development. A generic development process, front-end process.<br>Identifying Customer Needs- Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. | |
| | | |
| **Unit-2** | **Product Planning & Specifications** | 06 Hours |
| | The product planning process- identify opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process.<br>Product Specifications- What are specifications, when are specifications established, establishing target specifications, setting the final specifications. | |
| | | |

| | | |
|---|---|---|
| **Unit-3** | **Concept Generation, selection and testing** | 06 Hours |
| | Concept generation -clarify the problem, search externally & internally, explore systematically, reflect on the results and the process.<br>Concept Selection- Overview of methodology, concept screening, and scoring.<br>Concept Testing- purpose of concept test, choose a survey population & format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. | |
| | | |
| **Unit-4** | **Product Architecture & Development Economics** | 06 Hours |
| | Product architecture- implications & establishing the architecture, variety and supply chain considerations, platform planning and related system level design issues.<br>Product Development Economics- Elements of economic analysis, Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis. | |
| | | |
| **Unit-5** | **Prototyping** | 05 Hours |
| | Prototyping basics, principles of prototyping, technologies, planning for prototypes. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Draw complex geometries of conceptual product components in sketch mode | 06 Hours |
| Experiment 2 | Working with advanced modeling tools | 06 Hours |
| Experiment 3 | Assembly modelling | 08 Hours |
| Experiment 4 | Practice methods and techniques of prototype making using sheet metal fabrication | 08 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | **Total** | **56 Hours** |

**2.5 Text Book and References**

**Text Books:**

1. Karl.T.Ulrich and Steven D Eppinger, Product Design and Development- Irwin/McGrawHill - 2000.
2. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly - 2002

**Reference Books:**

1. Chitale, A. C. and Gupta, R. C., Product Design and Manufacturing, PH1, 3rd Edition, 2003.
2. Tim Jones and Butterworth Heinmann, New Product Development, Oxford, UCI,1997

**Course: Tribology**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Tribology** |
| Course Code | **20MDE5034** |
| Semester | **I Semester** |

**1.Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 4 | 2 | - | 2 | 6 |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| **Theory Component** | **2x14** | **28 Hours** |
| **Lab Component** | **2x14** | **28 Hours** |
| **Open-ended Project (With Industrial Collaboration based on relevance)** | **2x14** | **28 Hours** |
| **Total** | | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2.1 Course Details**

**2.2 Course Aim and Summary**

The course will equip students with the necessary knowledge on various types of bearings, and the design of bearings by considering various factors affecting the performance.

**2.3Course Objectives**

The objectives of the Course are:

- Understand the steps involved in fundamentals of tribology
- Able to know how to use the technology to gather and analyze data for bearings applications
- Identify different types of bearings and lubrication and examine the applications and troubleshoot problems
- Provide a broad based and discipline mechanism learning concept for tribology

**Laboratory Component**

The student will be able to

- Test and understand the bearing material wear properties
- Understand the lubricity of various oils
- Design the bearing based on fatigue behavior
- Use of experiments and MATLAB tools for tribological behavior and bearing design

### 2.4 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Expalin basic and fundamental skills for tribological analyses | L3 |
| CO2 | Demonstrate the importance of tribology and extending product life of bearings. | L3 |
| CO3 | Methodologies of design and troubleshooting tribological and EHL systems | L4 |
| CO4 | Use experimental set-up for prediction of tribological behaviour | L3 |
| CO5 | Apply mathematical tool such as MATLAB for bearing design | L3 |

### 2.5 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to Tribology** | 08 Hours |
| | Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers. Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems. | |
| | | |
| **Unit-2** | **Hydrostatic Bearings** | 08 Hours |
| | Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings. | |
| | | |
| **Unit-3** | **Journal Bearings** | 10 Hours |
| | Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. | |
| | | |
| **Unit-4** | **Porous Bearings-** | 08 Hours |
| | Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages. Antifriction bearings- Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings. | |

| | | |
|---|---|---|
| **Unit-5** | **Hydrodynamic Lubrications** | 08 Hours |
| | Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on 46 performance, Numerical problems, EHL Contacts- Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution. | |
| | **Total =** | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiments 1 & 2 | Multipurpose Friction and Wear test | 14 Hours |
| Experiment 3 | Use MATLAB for design of hydrostatic and journal bearings | 07 Hours |
| Experiment 4 | Use Ansys for bearing analysis | 07 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | **Total** | **56 Hours** |

## 2.6 Text Book and References


**Text Books:**

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

**Reference Books:**

1. Dudley D.Fulier., Theory and practice of Lubrication for Engineers, New York Company.1998
2. Moore., Principles and applications of Tribology, Pergamon press, 1975.
3. Pinkus 'O' Stemitch., Theory of Hydrodynamic Lubrication.
4. Stachowiak, G. W, Batchelor, A W., Engineering Tribology, Elsevier publication 1993.
5. Butterworth., Hydrostatic and hybrid bearings, 1983.

**Course: ROBOTICS**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **ROBOTICS** |
| Course Code | **20MDE5035** |
| Semester | **I Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project (With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

The course will equip students with the functional knowledge of the robot components and their control systems, motion analysis, mathematical representation and kinematics. The course introduces to the robot programming for various applications. Students will also gain hands-on experience on control and analysis of robots using MATLAB and Simulink software.

**2.2 Course Objectives**

The objectives of the Course are:

- To understand the basic engineering knowledge for the design of robots
- To describe spatial descriptions and transformations
- To explain manipulator kinematics and trajectory generation concepts
- To discuss the robot programming for various applications
- To teach students about basic robotics through lectures and simulations

**Laboratory Component**

- To familiarize the process of building a robot using MatLab.
- To calculate inverse kinematics for a simple 2-D manipulator.
- To demonstrate how to control a robot to follow the desired path using a robot simulator.
- To demonstrate how the inverse kinematics block can drive a manipulator along a specified trajectory.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Apply the basic engineering knowledge for the design of robots | L3 |
| CO2 | Illustrate the spatial descriptions and transformations | L2 |
| CO3 | Apply the manipulator kinematics and trajectory generation concepts | L2 |
| CO4 | Demonstrate the programming principles for robot control. | L3 |
| CO5 | Demonstrate the process of building a robot using MatLab | L4 |
| CO6 | Demonstrate the path following and trajectory control modeling using Simulink | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 05 Hours |
| | A brief history of robotics, robot anatomy, work volume, links, joint and joint notation scheme, degrees of freedom, arm configuration, wrist configuration, end-effector, robot drive systems, control systems, precision of movement, robotic sensors, robot programming and work cell control, robot applications. | |
| | | |
| **Unit-2** | **Coordinate Frames, Mapping and Transforms** | 06 Hours |
| | Coordinate Frames, Mapping: Mapping between rotated frames, mapping between translated frames, Mapping between rotated and translated frames, description of objects in space, transformation of vectors; rotation and translation of vectors, combined rotation and translation of vectors, composite transformation, fundamental rotation matrices, Euler angle representation. | |
| | | |
| **Unit-3** | **Robot Kinematics and Dynamics** | 06 Hours |
| | Introduction, description of links and joints, kinematic modeling of the manipulator, Denavit-Hartenberg notation, kinematic relationship between adjacent links, 2-DOF planar manipulator arm, kinematic model of a cylindrical arm, articulated arm kinematic model, robot arm dynamics, manipulator dynamics-construction of manipulators, Lagrangian formulation and N-E formulation. | |
| | | |
| **Unit-4** | **Path planning & Programming** | 06 Hours |
| | Introduction, general considerations in path description and generation, joint-space schemes, cartesian-space schemes, geometric problems with Cartesian paths, description of paths with a robot programming language, methods of robot programming, lead through programming methods, robot program as a path in space, motion interpolation, wait, signal, and delay commands, branching. | |
| | | |

| | | |
|---|---|---|
| **Unit-5** | **Robot Sensors and Machine Vision** | 05 Hours |
| | Transducers and sensors, sensors in robotics, tactile sensors; touch and force sensors, force sensing wrist, proximity and range sensors, uses of sensors in robotics, introduction to machine vision, sensing and digitizing, imaging devices, lighting techniques, analog to digital signal conversion, image storage, image processing and analysis | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Demonstration of the process of building a robot using MatLab | **28 Hours** |
| Experiment 2 | 2-D Path Tracing With Inverse Kinematics | |
| Experiment 3 | Path Following for a Differential Drive Robot | |
| Experiment 4 | Trajectory Control Modeling With Inverse Kinematics | |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

### 2.5 Text Book and References

**Text Books:**

1. John J. Craig, Introduction to Robotics, Third Edition, Pearson India Education Services Pvt. Ltd, 2015
2. Mikell P Groover, Mitchel Weiss, Industrial Robotics, Second Edition, McGraw Hill Education (India) Private Limited, 2012
3. Ashitava Ghosal, Robotics-Fundamental Concepts and Analysis, Oxford University Press, 2006.

**Reference Books:**

1. Fu, K, S., Gonzalez R. C., and Lee C.S.G., Robotics Control, Sensing, Vision and Intelligence, McGraw Hill, Thirteenth reprint 2015.
2. Schilling R. J., Fundamentals of Robotics, Analysis and Control, PHI, 2006.
3. Niku, S. B. Introduction to Robotics Analysis, Systems, Applications, Pearson Education, 2008.
4. R K Mittal, I J Nagrath, Robotics and Control, Tata McGraw-Hill Education, 2003

**Course: Digital Control Systems**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Digital Control Systems** |
| Course Code | **20MDE5036** |
| Semester | **I Semester** |

**1.Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2.Course Details**

**2.1 Course Aim and Summary**

The course will equip students with the necessary knowledge on digital/analog conversion, state equations and transfer functions. Also, the controllability and observability of LTI systems and the correlation between the time response and root locations in S plane and Z plane. This course also provides the ample knowledge on PID controller design and analysis.

**2.2 Course Objectives**

The objectives of the Course are

- Ability to carry out the stability analysis and control systems.
- Ability to learn processors for industrial applications.
- To understand the state space approach
- To understand PID controllers

**Laboratory Component**

The student will be able to

- To know how to model, analyze control systems using MATLAB software
- Learn the concepts of control system and use their skill for getting solutions

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Solve problems using z-transform, inverse z- transform techniques. | L3 |
| CO2 | Know the advantage of state variable technique, controllability, observability for effective design of controller using digital technique | L3 |
| CO3 | Develop competency in controller design | L3 |
| CO4 | Analyse the time response of controllers | L4 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Sampling and holding** | 06 Hours |
| | Sample and hold device D/A, A/D conversion – Z transform – Inverse Z transform – properties – Pulse transfer function and response between sampling intervals – Reconstruction. | |
| | | |
| **Unit-2** | **State equations of discrete data systems** | 06 Hours |
| | State transition equations – Relationship between state equation and transfer functions - Characteristic equations – Eigen value – eigen vector –Diagonalization of Matrix – Jordan canonical form – Methods of computing state transition matrix –State diagram – Decomposition of discrete data transfer function | |
| | | |
| **Unit-3** | **Controllability and observability of linier time invariant discrete data systems** | 06 Hours |
| | Relationships between controllability, observability and transfer function-Stability of linier discretecontrol system – Stability tests – Bilinear transformation method – Jury's stability test | |
| | | |
| **Unit-4** | **Correlationbetween time response and root locations in S plane and Z plane** | 05 Hours |
| | Direct design in Z and W plane – State space design – Design via pole placement, digital PID controller design. | |
| | | |
| **Unit-5** | **Selection of processors** | 05 Hours |
| | Mechanization of control algorithms – Merits and demerits – Applications of temperature control – Control of electric drives. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | State Space Modelling – relationship between state space model and transfer function | **28 Hours** |
| Experiment 2 | Determining the controllability and observability of various state space models | |
| Experiment 3 | Design of Controller using Pole Placement Method | |

| | | |
|---|---|---|
| Experiment 4 | PID Controller Design | |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

## 2.5 Text Book and References


| **Text Books:** | |
|---|---|
| 1. Ogata, K. Discrete Time Control Systems, Pearson Education Asia, 2001<br>2. Gopal, M. Digital Control and State Variable Methods, Tata McGraw Hill,1999 | |
| **Reference Books:** | |
| 1. Kuo, B.C. Digital Control Systems, Oxford University Press, 1992<br>2. Gopal, M. Digital Control Engineering, Willey Eastern Ltd.1989<br>3. Laboratory manual, school of engineering, DSU | |

**Course: SENSORS & SIGNAL CONDITIONING**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Sensors & Signal Conditioning** |
| Course Code | **20MDE5037** |
| Semester | **I Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The aim of this course is to give an introduction of various sensors and process them for making suitable for data acquisition applications

**Course Objectives**

The objectives of the Course are:

- To instill knowledge of advanced sensor systems.
- To provide an application oriented approach in instrumentation.

### 2.2 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Explain the characteristics of instrumentation system | L2 |
| CO2 | Identify the most suitable method of sensing and transduction for an application. | L2 |

| | | |
|---|---|---|
| CO3 | Describe various types magnetic sensors and their applications | |
| CO4 | Discuss analog and digital instrumentation aspects | |
| CO5 | Design instrumentation and associated data acquisition system. | |
| CO6 | Develop data acquisition system for any typical mechanical applications | |

**2.3 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Basic Concepts** | 06 Hours |
| | Basic Concepts of Measurements and characteristics of an Instrumentation System-System configuration, Problem analysis, Basic characteristics of measuring, Calibration, Generalized measurements, Zero order, First order, second order system, Dead time element. | |
| | | |
| **Unit-2** | **Sensors and Transducers** | 06 Hours |
| | Electromechanical sensors, Resistance type, Potentiometer, Strain gauge, Resistance thermometer, RTD, Inductance type, Capacitance type, Piezo Electric type. | |
| | | |
| **Unit-3** | **Magnetic sensors** | 06 Hours |
| | NMR, MRI, Fiber optic sensors, Opto electronic sensors, CCD, Digital transducers. | |
| | | |
| **Unit-4** | **Analog and Digital Instrumentation** | 05 Hours |
| | Operational Amplifiers, Signal generation, Signal processing, Filtering and signal analysis. | |
| | | |
| **Unit-5** | **Data Acquisition, Conversion, Transmission and Processing** | 05 Hours |
| | Signal Conditioning of the inputs – Single channel and Multichannel data acquisition, Data conversion, Multiplexers, Sample and hold circuits, Data transmission systems, Pulse code formats, Modulation techniques, Telemetry system. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Measurement & processing of different types of signals | 08 Hours |
| Experiment 2 | Open-ended-Project on Data acquisition<br>(With Industrial Collaboration based on relevance) | **20 Hours** |
| | Total | **28 Hours** |

## 2.4 Text Book and References

| **Text Books:** | |
|---|---|
| 1. Nubert, H.K.P., Instruments Transducers, Clarendon Press, Oxford, 1963<br>2. Ernest O. Doebelin, Measurement System Application & Design McGraw Hill, New York, 1983. | |
| **Reference Books:** | |
| 1. Ramon Pallas-Areny, John G. Webster, Analog Signal Processing, A Wiley Interscince Publication, John Wielly & Sons, INC<br>2. Fernando E. Valdes-Perez Ramon Pallas-Areny, Microcontrollers, CRC Press, Taylor and Francis Group | |

**Course: Design of Hydraulic and Pneumatic Systems**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Design of Hydraulic and Pneumatic Systems** |
| Course Code | **20MDE5038** |
| Semester | **I Semester** |

**1.Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **5** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

Conduction of Classes: **As per Time Table**

**2.1Course Details**

**2.2 Course Aim and Summary**

The course will equip students with the necessary knowledge to design hydraulic and pneumatic systems. Design of hydraulic and pneumatic systems is aessential tool that is extensively used in industry and research institutions. Students will also gain hands-on experience in designing the hydraulic and pneumatic systemsusing software Automation Studio to solve realistic engineering problems.

**2.3 Course Objectives**

The objectives of the Course are:

- To understand fundamentals of Hydraulic and Pneumatic systems
- To design simple Hydraulic and Pneumatic circuits.
- To design circuits for low cost automation. Demonstrate ability to make use of commercial software to solve complex problems.
- Demonstrate ability to make use of commercial software to solve complex problems.

**Laboratory Component**

The student will be able to

- Familiarize in fluid power automation and different components of Hydraulics, pneumatics, electro hydraulic / electro pneumatic and PLC based systems.

- Design, analyze and interprethydraulic and pneumatic circuitsfor mechanical systems using Automation Studio.
- Learn the concepts of hydraulic and pneumatic systems, and use their skill for getting solutions for real systems.

**2.4 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Comprehend the principles, features and functions of hydraulic pumps and actuators. | L3 |
| CO2 | Understand the concepts of flow control valves and regulators. | L2 |
| CO3 | Realize the different types of hydraulic circuits and systems, and design the same. | L3 |
| CO4 | Know the principles, features and functions of pneumatic pumps and actuators. | L3 |
| CO5 | Recognize the working of different pneumatic circuits and systems, and design pneumatic circuits and systems. | L5 |
| CO6 | Design, develop and analyse different types ofhydraulic and pneumatic circuitsand real systems. | L3 |

**2.5 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Hydraulic Systems and Actuators** | 05 Hours |
| | Basic principles- Hydraulic Principles. Hydraulic Power Generators- Selection and specification of pumps, pump characteristics. Hydraulic Actuators - Linear, Rotary - Selection Characteristics. | |
| | | |
| **Unit-2** | **Control and Regulation Elements** | 06 Hours |
| | Hydraulic Valves: Pressure, Flow, Direction Controls- Proportional Control valve. Fluid power symbols. | |
| | | |
| **Unit-3** | **Design of Hydraulic Circuits** | 06 Hours |
| | Reciprocating, Quick return, Sequencing, synchronizing and other industrial circuits like press circuits - hydraulic milling machine - grinding, planning, copying, forklift, earth mover circuits - design and selection of components - safety and emergency mandrels. Selection and sizing of components-calculation of frictional head loss-equivalent length for various components- actuator load calculation- pump sizing. | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **Pneumatic Systems and Actuators** | 05 Hours |
| | Pneumatic system fundamentals: FRL, actuators and valves. Logic Circuits - Position - Pressure Sensing, switching, electro-pneumatic. | |
| | | |
| **Unit-5** | **Design of Pneumatic Circuits** | 06 Hours |
| | Design of Pneumatic circuits using - Karnaugh maps. Cascade-Step counter. Installation, Maintenance and Special Circuits- Pneumatic equipment - selection of components - design calculations -application - fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Speed Control cirtcuits for double acting cylinder - Synchronization circuit for two cylinders - Continuous reciprocation of double acting cylinder - Sequencing of two-cylinder circuits - Cascading circuit for trapped signals-2 groups - Cascading circuit for trapped signals- 3 groups - Logic Circuits and /or | 7 Hours |
| Experiment 2 | Basic Electro Pneumatic Circuits: Continuous reciprocation of cylinder (with timer and counter) Sequencing of two cylinders - Force, Velocity calculations in Hydraulic Linear actuation - Speed Control of AC Servo Motor using open and closed loop control - PLC Application Trainer - PLC Control Pneumatic/ Hydraulic linear actuator circuits | 7 Hours |
| Experiment 3 | Water Level Controller using PLC - PLC Controlled Material Handling System - Process Control using Virtual Instrumentation like Automation Studio | 7 Hours |
| Experiment 4 | Run A Stepper Motor: For Required Angle - Characteristics of Inductive, capacitive and photoelectric proximity sensors - Mini Project | 7 Hours |
| | Open-ended-Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

## 2.6 Text Book and References

**Text Books:**

1. Majumdar, S. R. Oil hydraulics and Pneumatics, Tata McGraw Hill, 2003.
2. Bolton, W. Pneumatic and hydraulic systems, Butterworth Heinemann, 1997.

**Reference Books:**

1. Anthony Esposite, Fluid Power with Applications, Pearson Education, 2000.
2. Andrew Parr, Hydraulics and Pneumatics, Jaico, 1999.
3. Laboratory Manual, School of Engineering, DSU.

**Course: Lean Manufacturing**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Lean Manufacturing** |
| Course Code | **20MDE5039** |
| Semester | **I Semester** |

**1.Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project (With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**
**Conduction of Classes: As per Time Table**

**2.Course Details**

**2.1 Course Aim and Summary**

The course will equip students with the necessary knowledge to use the lean manufacturing to relate to Just in time production, Kanban systems, Product costing and 5S.Lean manufacturing tool that is extensively used in many industry especially Toyota . Students will also gain experience by visiting the lean manufacturing implementing industry by conducting a mini project to solve realistic engineering problems.

**2.2 Course Objectives**

The objectives of the Course are:

- Introduce the various aspects of lean Manufacturing like just in time, Kanban systems,
- Understanding the Benefits of lean manufacturing, Types of wastes, Reduction of wastes.
- Understanding the system manufacturing, manufacturing strategy, design considerations for manufacture component and quality systems.
- Identify the strategic issues like Training. Lean accounting, Activity based costing Product costing materials for effective manufacturing and make a future state for lean manufacturing.
- Use of Opportunity to learn the fundamental principles of lean in manufacturing

**Laboratory Component**

The student will be able to

- To know the lean manufacturing implementation by visiting industry.
- Learn the concepts of just in time, Kanban systems, Kaizen and 5S.
- Conducting a mini project in lean manufacturing tool to solve realistic engineering problems.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | **Illuminate** the Brief history of lean manufacturing, Just in time production, Toyota systems, Kanban systems | L2 |
| CO2 | **Describe** the lean manufacturing for Assessment tools, Implementing lean manufacturing and Science behind lean manufacturing. | L2 |
| CO3 | **Evaluating** the Lean accounting like Product costing, Volume adjusted costing and Focused factory concept. | L3 |
| CO4 | **Explain** the Group technology coding classification , Kaizen, 5S,TPM Automation , Yoko poko , Design Root cause analysis ,Failure models and effects | L2 |
| CO5 | **Analysing** the lean manufacturing by visiting implemented industry. | L5 |
| CO6 | **Evaluating** and conducting a mini project to solve realistic engineering problems on lean manufacturing. | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **General** | 05 Hours |
| | Brief history of lean manufacturing, Just in time production, Toyota systems, Kanban systems, Kanban rules, Benefits of lean manufacturing, Types of wastes, Reduction of wastes. | |
| | | |
| **Unit-2** | **Lean manufacturing** | 05 Hours |
| | Principles - Basic tools - Techniques - Definition - Assessment tools- Implementing lean manufacturing – Science behind lean manufacturing – Capacity utilization - Variability – Delivery | |
| | | |
| **Unit-3** | **Strategic issues:** | 05 Hours |
| | Actions - Issues - Focus - Leadership - Management of teams – Training. Lean accounting: Activity based costing - Product costing - Volume adjusted costing – Focused factory concept – Building strategic advantage through enterprise wide | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **Value stream and process mapping** | 05 Hours |
| | Overview - Where to use - Step by step approach –How to use – Reduce stream mapping – Present and future states - VSM symbols – Process mapping - Detailed instructions - limits – facilitation. | |
| | | |
| **Unit-5** | **Cellular manufacturing:** | 08 Hours |
| | Work cell – Cell design - Facility planning – Plant layout – Balancing the work in work cells – Tact time – Defining - Benefits - Uses - Limitations –Facilities planning tools. Group technology coding classification - Productivity Improvement Aids - Kaizen – Kanban - 5S - TPM - Automation - Jidoka – Mistake proofing – Yoko poko Design Root cause analysis - Failure models and effects. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Introduction to the lean manufacturing and Science behind the lean. | 7 Hours |
| Experiment 2 | manufacturing process tools just in time (JIT) | 7 Hours |
| Experiment 3 | Learning of Kanban , Kaizen , 5s systems. | 7 Hours |
| Experiment 4 | Yoko poko Design Root cause analysis and Failure models and effects. | 7 Hours |
| Open-ended Project | Open-ended Project (With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

**2.5 Text Book and References**


| | |
|---|---|
| **Text Books:** | |
| 3. 1. Taiichi Ohno, (1988), The Toyota Production System (Beyond Large Scale production), Portland, Oregon Productivity Press | |
| **Reference Books:** | |
| 4. 1.Kigoshi Suzaki, (1988), The New Manufacturing Challenge, Free Press, New York.<br>5. 2. Shigeo Shing, (1989), Study of Toyota Production System, Portland, Oregon | |
| | |

**Course: Smart Materials and Structures**

| | |
|---|---|
| School | School of Engineering |
| Department | Mechanical Engineering |
| Programme | M. Tech programme |
| Specialization | Design Engineering |
| Course Title | Smart Materials and Structures (Theory & Practice) |
| Course Code | 20MDE5040 |
| Semester | I Semester |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2.Course Details**

**2.1 Course Aim and Summary**

The course will equip students with the necessary knowledge on sensors, actuators and transducers. It also emphasizes on Design, Analysis, Manufacturing and Applications of Engineering Smart Structures andProducts. It discusses on various case studies incorporating design, analysis, manufacturing and applicationissues involved in integrating smart materials and devices with signal processing andcontrol capabilities to engineering smart structures and products.

**2.2 Course Objectives**

The objectives of the Course are:

- Understand the concept of MEMS and Microsystems.
- Understand the diverse technological and functional approaches andapplications.
- Provides an insight of micro sensors, actuators and micro fluidics.

**Laboratory Component**

The student will be able to

- Gain knowledge on smart material-based mechanical applications
- Experimentally analyze the vibration characteristics of the systems using sensors.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Understand the physical properties of smart materials. | L2 |
| CO2 | Study the characteristics of the system using sensors and actuators. | L2 |
| CO3 | Analyse the responses of Static and Dynamic systems | L3 |
| CO4 | Design, analyse and fabricate smart structures for various applications. | L3 |
| CO5 | Determine the vibration characteristics of the systems using sensors experimentally. | L5 |
| CO6 | Detect damage using Electro-Mechanical Impedance (EMI) Technique | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Overview of Smart Materials** | 06 Hours |
| | Overview of Smart Materials, Structures and Products Technologies. Smart Materials (Physical Properties) - piezoelectric materials, magneto strictive, electro strictive materials, magneto electric materials. Magneto rheological fluids, electro rheological fluids, shape memory materials, fiber-optic sensors | |
| | | |
| **Unit-2** | **Sensors and Actuators** | 06 Hours |
| | Smart Sensor, Actuator and Transducer Technologies - smart sensors-accelerometers, force sensors, load cells, torque sensors, pressure sensors, microphones, impact hammers, MEMS sensors, sensor arrays smart actuators: displacement actuators, force actuators, power actuators, vibration dampers, shakers, fluidic pumps, motors smart transducers, ultrasonic transducers, sonic transducers, air transducers. | |
| | | |
| **Unit-3** | **Measurement and Control** | 06 Hours |
| | Measurement, Signal Processing, Drive and Control Techniques- quasi-static anddynamic measurement methods, signal-conditioning devices, constant voltage, constantcurrent and pulse drive methods; calibration methods, structural dynamics andidentification techniques, passive, semi-active and active control, feedback and feedforward control strategies. | |
| | | |
| **Unit-4** | **Smart Structures** | 05 Hours |
| | Design, Analysis, Manufacturing and Applications of Engineering Smart Structures andProducts - Case studies incorporating design, analysis, manufacturing and | |

| | | |
|---|---|---|
| | applicationissues involved in integrating smart materials and devices with signal processing andcontrol capabilities to engineering smart structures and products. | |
| | | |
| **Unit-5** | **Applications** | 05 Hours |
| | Emphasis on structures, automation and precision manufacturing equipment, automotive, consumer products, sporting products, computer and telecommunicationsproducts, medical and dental tools and equipment. | |
| | **Total** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Vibration Characteristics of Cantilever Beam Using Piezoelectric Sensors | 7 Hours |
| Experiment 2 | Identification of High Frequency Modes of Beam in "Free-Free" Conditions Using ElectroMechanical Impedance (EMI) Technique | 7 Hours |
| Experiment 3 | Forced Excitation of Steel Beam Using Portable Shaker | 7 Hours |
| Experiment 4 | Damage Detection and Qualitative Quantification Using Electro-Mechanical Impedance (EMI) Technique | 7 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | **Total** | **56 Hours** |

## 2.5 Text Book and References


**Text Books:**

1. Culshaw, B., Smart Structures and Materials, Artech House, Boston, 1996.
2. Srinivasan, A. V., Smart Structures: Analysis and Design, Cambridge University Press, Cambridge; New York, 2001

**Reference Books:**

1. Uchino, K., Piezoelectric Actuators and Ultrasonic Motors, Kluwer Academic Publishers, Boston, 1997.
2. Otsuka, K. and Wayman, C. M., Shape Memory Materials – CambridgeUniversity Press, Cambridge; New York, 1996.
3. Gandhi, M. V. and Thompson, B.S, Smart Materials and Structures, Chapman and Hall, London; New York, 1992

**Course: Mechatronics System Design**

| | |
|---|---|
| School | School of Engineering |
| Department | Mechanical Engineering |
| Programme | M. Tech Programme |
| Specialization | Design Engineering |
| Course Title | Mechatronics System Design |
| Course Code | 20MDE5041 |
| Semester | II Semester |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

Mechatronics system design deals with the design of controlled electromechanical systems by the integration of functional elements from a multitude of disciplines. It starts with thinking how the required function can be realized by the combination of different subsystems according to a systematic step-by-step engineering design approach applied to a realistic mechatronics design problem.

### 2.2 Course Objectives

The objectives of the Course are:

- To educate the student regarding integration of mechanical, electronic, electrical and computer systems in the design of CNC machine tools, Robots etc.
- To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems
- To provide a hands-on experience to model a mechatronic system using mechanical and electronic components & to control them.

**Laboratory Component**

The student will be able to

- Modelling and analysis of basic hydraulic, pneumatic and electrical circuits using MATLAB Software.
- Study of hydraulic, pneumatic and electro-pneumatic circuits

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | This course makes the student to appreciate multi-disciplinary nature of modern engineering systems. | L3 |
| CO2 | After undergoing this course, the student is in a position to understand how mechatronics systems can be designed and developed. | L2 |
| CO3 | Students will learn to use different electronics components and how to control them for different applications. | L3 |
| CO4 | Students will learn how to acquire data from a real time system and how to use that for betterment of the system. | L3 |
| CO5 | Students will have a hands-on experience on how to integrate electronics in existing mechanical systems | L5 |

**2.4 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 06 Hours |
| | Definition and Introduction to Mechatronic Systems. Modelling & Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. | |
| | | |
| **Unit-2** | **Electrical Actuation Systems** | 06 Hours |
| | Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. System Models- Mathematical models - mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. | |
| | | |
| **Unit-3** | **Signal Conditioning-** | 05 Hours |
| | Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. | |
| | | |

| | | |
|---|---|---|
| **Unit-4** | **MEMS and Microsystems** | 06 Hours |
| | Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. Data Presentation Systems-Basic System Models, System Models, Dynamic Responses of System | |
| | | |
| **Unit-5** | **Advanced Applications in Mechatronics** | 05 Hours |
| | Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, Automated Manufacturing – Artificial intelligence in Mechatronics – Fuzzy Logic Applications in Mechatronics – Micro sensors in Mechatronics. | |
| | **Total** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Construction of PCB, microcontroller programming, implementation of control methods, introduction to PID Control, etc. | 07 Hours |
| Experiment 2 | Construction of a printed-board circuit and confirmation of the sensor signal processing function | 07 Hours |
| Experiment 3 | Modelling and analysis of basic hydraulic, pneumatic and electrical circuits using MATLAB Software | 07 Hours |
| Experiment 4 | Study of hydraulic, pneumatic and electro-pneumatic circuits | 07 Hours |
| Experiment 5 | Open-ended Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | **Total** | **56 Hours** |

## 2.5 Textbook and References

**Text Books:**


1. Bolton, W. Mechatronics - Addison Wesley Longman Publication, 1999
2. Tai-Ran Hsu, MEMS and Microsystems Design and Manufacture- Tata McGraw-Hill Education, 2002


**Reference Books:**


1. Kamm, L. J., Understanding Electro-Mechanical Engineering an Introduction to Mechatronics - IEEE Press, 1st Edition, 1996.
2. Shetty and Kolk, Mechatronics System Design- Cengage Learning, 2009.
3. Mahalik, Mechatronics- Tata McGraw-Hill Education, 2003.

**Course: MODELLING AND SIMULATION**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **MODELLING AND SIMULATION** |
| Course Code | **20MDE5042** |
| Semester | II Semester |

## 1.Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2.Course Details

### 2.1 Course Aim and Summary

This course is aimed to impart basic understanding of Modeling and Simulation so that the students will find it easy to use this knowledge in profession for applying to various engineering systems and design.

### 2.2 Course Objectives

**Theory Component:**

- Gain hands training and experience on Simulation software.
- Developing skill to apply simulation software for goal driven system models.
- Acquire working knowledge in statistical techniques, modelling approach and systems simulation.

**Laboratory Component:**

- To impart the fundamental knowledge on using various Modeling and Simulation tools like MATLAB/PYTHON/ANSYS etc.
- To know various fields of engineering where these tools can be effectively used to improve the output of a product.
- To impart knowledge on how these tools are used in Industries by solving some real time problems using these tools.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Develop performance models for real world systems and will be able to solve those models through simulation and statistical techniques. | L3 |
| CO2 | Understand the behavior of modelling system and create model for simulation studies. | L2 |
| CO3 | Develop skills to apply simulation software to construct and execute goal-driven system models. | L3 |
| CO4 | Interpret the model and apply the results to resolve critical issues in a real world environment. | L3 |
| CO5 | Demonstrate the software tools like MATLAB/PYTHON/ANSYS in solving real time problems and day to day problems. | L5 |
| CO6 | Simulate the models for the purpose of optimum control by using software. | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to Simulation:** | 06 Hours |
| | Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study. Simulation studies related to Queuing systems, Inventory System etc. | |
| | | |
| **Unit-2** | **General Principles** | 05Hours |
| | Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling. Random Numbers theory | |
| | | |
| **Unit-3** | **Random Variate Generation** | 6 Hours |
| | Inverse Transform Technique- Probability density functions, convolution methods- Erlang distribution, Acceptance Rejection Technique Optimization Via Simulation: Meaning, difficulty, Robust Heuristics, Random Search. | |
| | | |
| **Unit-4** | **Data Input Modelling** | 05 Hours |
| | Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. Verification and Validation | |

| | | |
|---|---|---|
| | | |
| **Unit-5** | **Output Analysis** | 06 Hours |
| | Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations.<br>**Software:** Selection of Simulation Software, Simulation packages, Trend in Simulation Software. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Numerically calculation and MATLAB Simulation: Invariants, Principal stresses and strains with directions, Maximum shear stresses and strains and planes, Von-Mises stress, Calculate and Plot Stresses in Thick-Walled Cylinder | 8 Hours |
| Experiment 2 | Modelling and Simulation of Control Systems using MATLAB; Vibration Characteristics of a Spring Mass Damper System- Analytical Solutions, MATLAB Simulation, Correlation Studies. Torsion of Prismatic bar with Rectangular cross-section-Elastic solutions, MATLAB Simulation. | 6 Hours |
| Experiment 3 | Analysis of Structures: Static Analysis. Modal Analysis. Harmonic Analysis. Spectrum Analysis. Buckling Analysis, Analysis of Composites. | 6 Hours |
| Experiment 4 | Students are trained in 3D Modeling and Finite Element Software such as ProE, SolidWorks, ANSYS, as part of the Lab exercise. | 8 Hours |
| | Open-ended Project(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

**2.5 Text Book and References**


**Text Books:**

1. Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.
2. Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.
3. Averill Law & David M. Kelton, Simulation, Modelling and Analysis, TMH 3rd Edition, 2003.
4. Banks, J., J.S. Carson, B.L. Nelson, and D.M. Nicol, Discrete-Event System Simulation, Fourth Edition, Prentice-Hall, 2005.

**Reference Books:**

1. Gordon, G., System Simulation, PHI, 2006.
2. Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.
3. NarsinghDeo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN : 0-87692-028-8
4. Deo, System Simulation with Digital computer, PHI, 1978.
5. Francis Neelamkovil, Computer Simulation and Modelling, John Wiley and Sons, 1987.

**Course: Mechanism Design**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Mechanism Design** |
| Course Code | **20MDE5043** |
| Semester | II Semester |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **0** | **2** | **6** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

This course will make the students a thorough understanding of the various mechanism design and simulation with an ability to effectively use various mechanisms in real life problems. Students will also gain hands-on experience by using mechanism simulation software (ANSYS WORKBENCH or CATIA) to develop and simulate their unique mechanisms.

**2.2 Course Objectives**

The objectives of the Course are:

- Study the kinematic analysis and synthesis of mechanisms using graphical and analytical method.
- Understand the various quantitative and qualitative approaches for different mechanisms.
- Able to formulate, identify and solve mechanism problems.
- to get familiarized with the advanced mechanisms which are necessary to design for specific application.

**Laboratory Component**

The student will be able to

- Get familiarized with the advancements of kinematics & design
- Exposure to tools such as CATIA & ANSYS workbench

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Understand various mechanism along with Grubler's equation & Grashof's condition. | L3 |
| CO2 | performkinematic analysis of various mechanisms. | L4 |
| CO3 | Execute mechanism synthesis for specified positions of various mechanism using graphical method | L3 |
| CO4 | Perform mechanism synthesis for specified positions of various mechanism using analytical method | L3 |
| CO5 | Execute the plane motion analysis of different mechanism | L4 |
| CO6 | Demonstrate proficiency in the use of mechanism simulation software for kinematic analysis. | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Kinematic Analysis of Mechanism** | 06 Hours |
| | Terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms using various method Position Analysis - Vector loop Equations for 4 bar, Slider Crank, Six bar linkages, velocity and acceleration analysis | |
| **Unit-2** | **Kinematic Mechanism synthesis - Graphical Method** | 06 Hours |
| | Type, Number and Dimensional Synthesis, Function Generation, Path Generation and Motion Generation, Graphical Methods Two Position, Three Position and Four Position Synthesis of 4-bar Mechanism, Slider Crank Mechanism. Guiding a body through two, three and four distinct positions. | |
| | | |
| **Unit-3** | **Kinematic Mechanism synthesis - Analytical Method** | 06 Hours |
| | Analytical Methods - Blotch's Synthesis, Freudestien's Method, Coupler curve Synthesis, Cognate linkages - The Roberts – Chebychev theorem. | |
| | | |
| **Unit-4** | **Advanced Kinematics of plane motion-I** | 06 Hours |
| | Introduction to plane motion. The Inflection circle, Euler – Savary Equation, Analytical and graphical determination of Bobillier's Construction, Collineation axis, Hartmann's Construction, Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis. | |
| | | |
| **Unit-5** | **Advanced Kinematics of plane motion-II** | 04 Hours |
| | Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle | |
| | **Total =** | **28 Hours** |

**Lab Component/open ended projects:**

| | | |
|---|---|---|
| Experiment 1 | Students are trained in Kinematics simulation software such as ANSYS WORK BENCH or CATIA as part of the Lab exercise. | 04 Hours |
| Experiment 2 | Modelling, simulate and analysis of a four-bar, slider crank, six-bar and any unique mechanism models. | 08 Hours |
| Experiment 3 | Model two different quick return mechanisms and do performance analysis (stroke length, cutting ratio) of those models. | 08 Hours |
| Experiment 4 | Synthesis a unique mechanism model using suitable mathematical approach, simulate and study the effects of link length and its orientation. | 08 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | **Total** | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**


1. Waldron, K.J. &Kinzel, G.L., Kinematics, Dynamics and Design of Machinery, Wiley, 2007.
2. Sandor, G. N and Erdman, A.G. Applied Mechanism Design, PHI, 1988.
3. Robert L Norton, Design of Machinery: An introduction to the Synthesis and Analysis of Mechanisms and Machines. Mcgraw-Hill, 3rd edition, 2003
4. Asok Kumar Mallik, Amitabha Ghosh, Gunter Dittrich, Kinematic Analysis and Synthesis of Mechanisms, CRC Press, 1st edition, 1994.


**Reference Books:**


1. Hall, A.S., Kinematics and Linkage Design, PHI.
2. Ambekar, A.G., Mechanism and Machine Theory, PHI, 2007.
3. David H. Myszka, Machines and Mechanisms, Pearson Education, 2005.

**Course: Industrial Design & Ergonomics**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech Programme** |
| Specialization | **Design Engineering** |
| Course Title | **Industrial Design & Ergonomics** |
| Course Code | **19MDE5044** |
| Semester | **II Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

The course will help students to understand the importance of ergonomics and design relevances; Man-machine interaction system and user-friendly design practice; Human compatibility, comfort and adaptability; Fundamentals of ergonomics: Physical (anthropometrics, human body- structure and function, posture, movement and biomechanics), Physiological (work physiology) and Psychological aspects (behavior, cognitive aspects and mental workload); Information processing, human error and risk perception; Visual performance and visual displays; environmental factors influencing human performance; Occupational stress; safety and health issues; Ergonomics criteria/check while designing; Design process involving ergonomics check and ergonomic design evaluation and Participatory ergonomics aspects.

**2.2 Course Objectives**

**Theory Component:**

- . Identify and quantify ergonomics problems and prioritize the outcomes
- To complete value added systems and controls
- Integrating ergonomics and anthropometric information into industrial design projects
- Apply practical design methodology and process to design project and objects

**Laboratory Component**

- To provide basic understanding to the students about the concept and significance of work study and ergonomics.
- To increase awareness of the need for and role of ergonomics in occupational health
- To impart thorough knowledge to the students about various techniques of work-study for improving the productivity of an organisation
- To inculcate analyzing skills among the students with respect to workplace design, working postures and lifting tasks
- To develop product designs in a systems context taking into account cognitive, social and behavioral human factors
- To apply design methods and generate process in the development of integrated product designs

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Students will be able to analyze and calculate the level of risk in a job causing stress, fatigue and musculoskeletal disorders and design appropriate work systems | L3 |
| CO2 | Develop design strategies, form detail concepts and communicate design proposals | L4 |
| CO3 | Work as per Occupational Safety and Health Administration (OSHA) guidelines | L1 |
| CO4 | Understand the significance of different physical factors like shape, size, color, form etc. | L2 |
| CO5 | Respond to the socio-economic and cultural contexts of industrial design and the ethical duties. | L5 |

**2.4 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **An approach to industrial design** | 08 Hours |
| | Elements of design structure for industrial design in engineering application in modern manufacturing systems. General approach to the man - machine relationship- workstation design-working position. | |
| | | |
| **Unit-2** | **Shapes & Size Considerations** | 05 Hours |
| | Shapes and sizes of various controls and displays-multiple, displays and control situations - design of major controls in automobiles, machine tools etc., and design of furniture -redesign of instruments | |
| | | |
| **Unit-3** | **Ergonomics and product design** | 05 Hours |
| | Ergonomics in automated systems- expert systems for ergonomic design. Anthropometric data and its applications in ergonomic, design-limitations of | |

| | | |
|---|---|---|
| | anthropometric data- use of computerized databases. Case study. | |
| | | |
| **Unit-4** | **Visual Effects of Line and Form** | 05 Hours |
| | The mechanics of seeing- psychology of seeing general influences of line and form. Aesthetic Concepts. Concept of unity- concept of order with variety -concept of purpose style and environment-Aesthetic expressions. Style- components of style-house style, observation style in capital goods, case study | |
| | | |
| **Unit-5** | **Color and light** | 05 Hours |
| | Colour and objects- color and the eye - colour consistency- colour terms- reactions to colour and colour continuation -colour on engineering equipment. Industrial Design in Practice - specifying design equipment- rating the importance of industrial design -industrial design in the design process. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Understanding of Man-Machine interactions - CNC Machine | 07 Hours |
| Experiment 2 | CATIA 3D Experience/ Fusion 360 Software - Ergonomics study | 07 Hours |
| Experiment 3 | Visual Effects Workshop on - Size, shape, form and color factors | 07 Hours |
| Experiment 4 | Practicing Occupational Safety and Health Administration (OSHA) guidelines - Industrial Visit | 07 Hours |
| Experiment 5 | **Open-ended Project**<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | **Total Hours** | **56 Hours** |

### 2.5 Textbook and References

**Text Books:**


1. Mayall W.H., Industrial Design for Engineers - London Hiffee books Ltd. -1988.
2. Brain Shakel (Edited) - Applied Ergonomics HandBook, Butterworth Scientific. London, 1988.


**Reference Books:**


1. Bridger, R. C., Introduction to Ergonomics, McGraw Hill Publications, 1995.
2. Sanders & McCormick, Human Factor Engineering, McGraw Hill Publications, 6th edition, 2002.

**Course: Additive Manufacturing**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Additive Manufacturing** |
| Course Code | **20MDE5045** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| **Credits** | **L** | **T** | **P** | **Hours/Week** |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

This course is intended to acquaint students with the concept of Additive Manufacturing (AM), various AM technologies, selection of materials for AM, pre and post processingof AM processes, and their applications in various fields.Students will be given experience of developing products through case studies in the lab. At the end of the module students will communicate concepts by virtual and physical appearance model.

### 2.2 Course Objectives

The objectives of the Course are to:

- Understand importance of additive manufacturing in advance manufacturing process.
- Explore the potential of additive manufacturing in different industrial sectors
- Apply 3D printing technology for additive manufacturing
- Acquire knowledge, techniques and skills to select relevant additive manufacturing process
- Familiarize with various materials that are used in additive manufacturing
- Know the principles, methods, possibilities and limitations of additive manufacturing process

**Laboratory Component**

The student will be able to

- Optimize the process parameters of FDM machine to improve the quality of the parts produced.
- Build engineering assemblies in plastic material with less process planning.
- Be able to explain the steps involved in Additive manufacturing process

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| **CO No.** | **Outcomes** | **Bloom's Taxonomy Level** |
|---|---|---|
| **CO1** | Define the various process & materials used in Additive Manufacturing | **01** |
| **CO2** | Identify, analyse and solve problems related to Additive Manufacturing processes. | **02** |
| **CO3** | Apply technique of CAD and reverse engineering for geometry transformation in Additive Manufacturing | **03** |
| **CO4** | Analyse and select suitable process to carry out improvement in Additive Manufacturing | **04** |
| **CO5** | Apply knowledge of Rapid tooling in additive manufacturing for various applications | **03** |
| **CO6** | Design and fabricate working models for the conceptual applications. | **06** |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 04 Hours |
| | Overview, history, Basic principle, advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification, Materials used and challenges in Additive Manufacturing, Tooling, Applications | |
| | | |
| **Unit-2** | **Additive Manufacturing Processes** | 07 Hours |
| | Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM), Micro- and nano-additive | |
| | | |
| **Unit-3** | **Pre-Processing in Additive Manufacturing** | 06 Hours |
| | Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, | |

| | | |
|---|---|---|
| | Transformations, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials, pre heating of powders. | |
| | | |
| **Unit-4** | **Post-Processing in Additive Manufacturing** | 05 Hours |
| | Post-processing equipments, support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques | |
| | | |
| **Unit-5** | **Rapid Tooling** | 06 Hours |
| | Introduction to Rapid tooling, classification, Direct and Indirect rapid tooling methods, Applications of additive manufacturing in rapid prototyping & rapid manufacturing, repairing and coating. Process optimization factors influencing accuracy, data preparationerrors,Partbuildingerrors,Errorinfinishing &influenceofbuildorientation. | |
| **Total =** | | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Review of CAD Modeling Techniques and Introduction to Rapid Prototyping | 02 Hours |
| Experiment 2 | Generating STL files from the CAD Models & Working on STL files | 02 Hours |
| Experiment 3 | Modeling & Assembly in Creative Designs in CAD Software | 08 Hours |
| Experiment 4 | Processing the CAD data in Catalyst software (Selection of Orientation, Supports generation, Slicing, Tool path generation) | 06 Hours |
| Experiment 5 | Fabricating the physical part on FDM- RP machine | 08 Hours |
| Experiment 6 | Demonstrating Creative Working Models | 02 hours |
| | Open-ended Project(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**

1. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014
2. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
3. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.

**Reference Books:**

1. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007
2. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006
3. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018

**Course: RESEARCH METHODOLOGY**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **RESEARCH METHODOLOGY** |
| Course Code | **20MDE5046** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

Understand basic concepts of survey, research techniques and data process methodologies. Organize and conduct a scientific research in a more appropriate manner with report writing and show research work in much of field work.

### 2.2 Course Objectives

The objectives of the Course are:

- To understand the different aspects of social and managerial research.
- To understand the approach and methods of managerial research.
- To develop a thorough understanding of the fundamental theoretical ideas and research.

**Laboratory Component:**

- To understand the research process and also the research methods.
- To comprehend the research design.
- To comprehend the tools of data collection.
- To analyse the validity and reliability of scale, Scale values.

- To analyse and understand the testing of hypothesis, Parametric and non parametric tests, multivariate analysis.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| **CO No.** | **Outcomes** | **Bloom's Taxonomy Level** |
|---|---|---|
| CO1 | This course makes the students to develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling. | L3 |
| CO2 | The Students will be able to have basic knowledge on qualitative research techniques | L2 |
| CO3 | The students will be able to have adequate knowledge on measurement & scaling techniques as well as the quantitative data analysis | L3 |
| CO4 | The students will be able to have basic awareness of data analysis-and hypothesis testing procedures | L3 |
| CO5 | The students will be able to have knowledge on Report writing, format of reports | L5 |
| CO6 | The students will be able to have basic knowledge on Research design and role of literature , importance of research and it's role. | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Meaning of research** | 08 Hours |
| | nature and scope of research, the research process and types of research, Definition of research problem-methods of problem formulation. Role of literature review in formulation of research problem, Research design, Uses and applications, Types of research designs, Exploratory, descriptive, experimental research designs. | |
| | | |
| **Unit-2** | **Survey and sample study** | 08 Hours |
| | sampling theories- random sampling and non-random sampling, Different methods of random and non-random sampling-sample size decisions, factors influencing sample size decision, Optimum sample size, Pilot survey. | |
| | | |
| **Unit-3** | **Methods and techniques of data collection** | 10 Hours |
| | Observation and survey methods, Tools of data collection, Questionnaire and interview schedule, Questionnaire preparation, attitude measurement, Scaling techniques, Different types of scales, Validity and reliability of scale, Scale values. | |
| | | |
| **Unit-4** | **Field work and data processing** | 08 Hours |
| | Classification and tabulation, Data summarization, analysis and interpretation of data, Univariate analysis, bivariate analysis, correlation and regression analysis, | |

| | | |
|---|---|---|
| | testing of hypothesis, Parametric and non parametric tests, multivariate analysis, Factor analysis, discriminate analysis, conjoint analysis, cluster Analysis. | |
| | | |
| **Unit-5** | **Report writing** | 08 Hours |
| | Types of reports, Substance of report, format of reports, Executive summary, Content of the report, Bibliography, References, Presentation of reports. | |
| **Total =** | | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Understanding the research process and also the research methods. | 4 |
| Experiment 2 | Comprehending the research design. | 6 |
| Experiment 3 | Comprehending the tools of data collection | 6 |
| Experiment 4 | Analysing the validity and reliability of scale, Scale values. | 6 |
| Experiment 5 | Analysing and understanding the testing of hypothesis, Parametric and non - parametric tests, multivariate analysis | 6 |
| | Open-ended Project(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

## 2.5 Text Book and References

| **Text Books:** | |
|---|---|
| 1. Poulin V Young, Scientific social Surveys and Research, Prentice Hall of India, New Delhi, 1984.<br>2. Kothari C.R, Research Methodology- Methods and Techniques, Vishwa Prakashan, New Delhi, 2001. | |
| **Reference Books:** | |
| 1. Gibaldi, Joseph, MLA Handbook for Writers of Research Papers, Affiliated East West Press Pvt. Ltd., New Delhi 2000. | |

**Course: Embedded Systems (Theory & Practice)**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **Embedded Systems** |
| Course Code | **20MDE5047** |
| Semester | **II Semester** |

1. **Course Size and Instruction Method**

| **Credits** | **L** | **T** | **P** | **Hours/Week** |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

The main aim of the course is to prepare the students to gain knowledge in the advanced materials and latest manufacturing process to recommend the feasibility, utilization of the materials that can be adopted in industries. The course involves new technology related to materials applications research, with focus on advanced device design, fabrication and integration, as well as new technologies based on novel materials.

**2.2 Course Objectives**

**Theory Component:**

- To introduce the technologies behind embedded computing systems.
- To introduce and discuss various software components involved in embedded system design and development.
- To expose students to the recent trends in embedded system design.

**Laboratory Component:**

- Introduction to Code warrior software
- Designing embedded systems using the software
- Integrating the software for Mechanical applications

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | **Understand** the role of individual components involved in a typical embedded system | L2 |
| CO2 | **Understand** the electronic and mechanical components used in automobile systems | L2 |
| CO3 | **Analyse**the characteristics of different computing elements and select the most appropriate one for an embedded system | L3 |
| CO4 | **Develop** simple tasks to run on an RTOS | L4 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Fundamentals of Embedded Systems** | 10 Hours |
| | Complex systems and microprocessors- Embedded system design process .Specifications- architecture design of embedded system- design of hardware and software components- structural and behavioural description. | |
| | | |
| **Unit-2** | **Hardware Software Co-Design and Program Modelling** | 08 Hours |
| | Fundamental Issues, Computational Models- Data Flow Graph, Control Data Flow Graph, State Machine,. Sequential Model, Concurrent Model, Object oriented model, UML | |
| | | |
| **Unit-3** | **Embedded Product Design** | 06 Hours |
| | Design and Development of Embedded Product – Firmware Design and Development – Design Approaches, Firmware Development Languages. | |
| | | |
| **Unit-4** | **Embedded Hardware and Firmware** | 08 Hours |
| | Integration and Testing of Embedded Hardware and Firmware- Integration of Hardware and Firmware. Embedded System Development Environment – IDEs, Cross Compilers, Disassemblers, Decompilers, Simulators, Emulators and Debuggers. | |
| | | |
| **Unit-5** | **RTOS based Design and Neyworks** | 10 Hours |
| | RTOS based Design – Basic operating system services. Interrupt handling in RTOS environment. Design Principles. Task scheduling models. How to Choose an RTOS. Case Study – MicroC/OS-II.Networks – Distributed Embedded Architectures, Networks for embedded systems, Network based design, Internet enabled systems. Embedded Product Development Life Cycle – Description – Objectives -Phases – Approaches1. Recent Trends in Embedded Computing. | |
| **Total =** | | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| 1 | Introduction to the software and the tools | 10 hours |
| 2 | Introduction to coding and running codes for control systems | 9 hours |
| 3 | Creating New Devices and integrating mechanical applications | 9 hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| **Total =** | | **56 Hours** |

## 2.5 Text Book and References

| **Text Books:** | |
|---|---|
| 1. J Staunstrup and Wayne Wolf, Hardware / Software Co-Design: Principles and Practice, Prentice Hall.<br>2. Jean J. Labrose, Micro C/OS II: The Real Time Kernel, 2e, CRC Press, 2002. | |
| **Reference Books:** | |
| 1. Raj Kamal, Embedded Systems: Architecture, Programming and Design, Third Edition, McGraw Hill Education (India), 2014.<br>2. Shibu K.V., Introduction to Embedded Systems, McGraw Hill Education (India), 2009.<br>3. Steave Heath, Embedded System Design, Second Edition, Elsevier.<br>4. Wayne Wolf , Computers as Components-Principles of Embedded Computer System Design, Morgan Kaufmann publishers, Third edition, 2012. | |
| | |

**Course: MICRO ELECTRO MECHANICAL SYSTEMS (MEMS)**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **MICRO ELECTRO MECHANICAL SYSTEMS (MEMS)** |
| Course Code | **20MDE5048** |
| Semester | **II Semester** |

1. **Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course will equip students with the necessary knowledge to use principles of physics to analyze and design MEMS, including sensors and actuators. The students will be exposed to various fabrication and characterization techniques to produce good quality MEMS devices. Students will also gain hands-on experience in using finite element analysis software ANSYS to design MEMS devices.

### 2.2 Course Objectives

The objectives of the Course are:

- To learn dynamics and modelling of micro-systems
- Understanding design and analysis of micro and Nano system applications
- Develop experience on microsystems for sensors and actuators applications
- To learn and characterize technology for MEMS

- Gain knowledge and have knowledge on state-of-the-art MEMS techniques for Microsystems
- Have an ability to identify, formulate and solve problems in the field of micro electrical systems.

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Classify the MEMS devices based on its application. | L2 |
| CO2 | Demonstrate the working principles of various mechanical sensors and actuators | L2 |
| CO3 | Apply the concept of microfluidics in various applications | L3 |
| CO4 | Design the various mechanical sensors and actuators | L4 |
| CO5 | Identify the suitable fabrication method for a MEMS device | L3 |
| CO6 | Choose the appropriate characterization techniques to characterize the MEMS systems. | L3 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 06 Hours |
| | Micro Electro-Mechanical Systems, Ultra Precision Engineering, Microsensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS : MOEMS; Magnetic MEMS; RF MEMS; Micro-fluidic Systems; Bio and Chemo – Devices; MEMS Packages and Design Considerations; MicroInstrumentation. | |
| | | |
| **Unit-2** | **Mechanical Sensors and Actuators** | 06 Hours |
| | Principles of Sensing and Actuation; Beam and Cantilever; Micro plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shear mode Piezo actuator; Gripping Piezo actuator; Inchworm Technology. | |
| | | |
| **Unit-3** | **Thermal and Fluidic Micro Sensors and Actuators** | 06 Hours |
| | Thermal sensors, Electrical Sensors, Chemical and Biosensors Electromagnetic and Thermal micro actuation, Mechanical design of micro actuators, examples, Micro Fluidic systems, Fluid actuation methods, micro valves, micro pumps, micro motors-Micro actuator systems : Ink-Jet printer heads, Micro-mirror TV Projector. | |
| | | |
| **Unit-4** | **MEMS- Design and Analysis** | 05 Hours |
| | Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modelling and simulation. | |

| | | |
|---|---|---|
| | | |
| **Unit-5** | **MEMS- Characterization** | 05 Hours |
| | Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force Microscopy (AFM), Scanning tunnelling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI) | |
| **Total =** | | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Analysis of the optimal dimension on the electrothermal microactuator, MEMS accelerometer and gyroscopes | 6 Hours |
| Experiment 2 | Paper based MEMS devices – Design and fabrication | 8 Hours |
| Experiment 3 | Simulation – Fabrication of MEMS devices | 6 Hours |
| Experiment 4 | Application projects of MEMS devices – using IMU | 8 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

## 2.5 Text Book and References


**Text Books:**

1. Rai-Choudhury P. MEMS and MOEMS Technology and Applications, PHI Learning Private Limited, 2009.
2. Stephen D. Senturia, Microsystem Design, Springer, 2001
3. Marc Madou, Fundamentals of Microfabrication, Taylor & Francis Group, 2002
4. Gregory Kovacs, Micromachined Transducers Sourcebook, McGraw Hill, 1998

**Reference Books:**

1. Bao, M.H., Micromechanical Transducers- Pressure sensors, accelerometers, and gyroscopes, Handbook, Elsevier, 2000.
2. Nadim Maluf, An Introduction to Micro electromechanical Systems Engineering, Artech House Publishers, 2000.
3. Stephen D. Senturia, Microsystems Design, Kluwer Academic Publishers, New York, November 2000

**Course: Automotive Electronics**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **Automotive Electronics** |
| Course Code | **20MDE5049** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| **Credits** | **L** | **T** | **P** | **Hours/Week** |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 7x14= 98 Hours**

| | | |
|---|---|---|
| Theory Component | 3x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| **Total** | | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The main aim of the course is to prepare the students to gain knowledge in the advanced materials and latest manufacturing process to recommend the feasibility, utilization of the materials that can be adopted in industries.The course involves new technology related to materials applications research, with focus on advanced device design, fabrication and integration, as well as new technologies based on novel materials.

### 2.2 Course Objectives

**Theory Component:**

- Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today’s automotive industry.
- Differentiate electronic and mechanical components used in automobile systems
- Apply concept of integration of system components
- Analyse and measure signal conversion parameters
- Obtain an overview of automotive diagnostics

**Laboratory Component:**

- Introduction to Proteus software
- Designing PCBs using the software
- Integrating the software for Mechanical applications

## 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| **CO No.** | **Outcomes** | **Bloom's Taxonomy Level** |
|---|---|---|
| CO1 | **Understand** theautomotive components, subsystems, design cycles, communication protocols and safety systems | L2 |
| CO2 | **Understand** the electronic and mechanical components used in automobile systems | L2 |
| CO3 | **Analyse** and measure signal conversion parameters | L3 |
| CO4 | **Apply** concept of integration of system components | L4 |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Automotive fundamentals overview** | 10 Hours |
| | Four stroke cycle, engine control, ignition system, spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system. Actuators – fuel metering actuators, fuel injector, ignition actuator,Exhaust After – Treatment System –AIR, catalytic converter, exhaust gas recirculation n (EGR), Evaporative emission systems | |
| | | |
| **Unit-2** | **Air/ fuel system** | 08 Hours |
| | Air/ fuel system – fuel handling, air intake system, air/ fuel management Sensors: Oxygen (02/EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP)sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure(MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature(ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor. | |
| | | |
| **Unit-3** | **Electronic Engine Control** | 08 Hours |
| | Electronic Engine Control – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control.<br>Vehicle motion control – cruise control, chassis, power brakes, antilock brake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension. | |

| | | |
|---|---|---|
| | | |
| **Unit-4** | **Communication** | 08 Hours |
| | Communication-serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS<br>Automotive Instrumentation– sampling, measurement & signal conversion of various parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system | |
| | | |
| **Unit-5** | **Automotive diagnostics** | 08 Hours |
| | Integrated body- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems, Automotive diagnostics – Timing light, engine analyzer, on-board diagnostic off- board diagnostics, expert systems. | |
| **Total =** | | **42 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| 1 | Introduction to the software and the tools | 10 hours |
| 2 | Picking, Placing And Wiring Up Components | 9 hours |
| 3 | Creating New Devices and integrating mechanical applications | 9 hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| **Total =** | | **56 Hours** |

## 2.5 Text Book and References

| | |
|---|---|
| **Text Books:** | |
| 1. Automobile Electrical and Electronic Systems" Tom Denton,Routledge,5 edition,2017.<br>2. Understanding automotive electronics, William b. Ribbens,SAMS/Elsevier publishing 6th edition,2002 | |
| **Reference Books:** | |
| 1. Automotive electrics automotive electronics systems and components,Robert Bosch Gmbh, john wiley& sons ltd., 5th sedition, 2007 | |

**Course: Optimization Techniques**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Optimization Techniques (Theory & Practical)** |
| Course Code | **20MDE5050** |
| Semester | **Department Elective** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: As per Time Table

## 2. Course Details

### 2.1 Course Aim and Summary

The course will equip students with the necessary knowledge to Optimization Techniques for solving the complex optimization problems that arise in engineering applications use the Direct search methods like Univariate method, Hook and Jeeves Genetic Algorithms, Simulated Annealing, and Tabu search methods for optimization. Students will also gain experience by visiting the Optimization Techniques implementing industry by conducting a mini project to solve realistic engineering problems.

### 2.2 Course Objectives

The objectives of the Course are:

- Concentrating on solving complex optimization problems that arise in engineering applications.
- Direct search methods like Univariate method, Hook and Jeeves' methods.
- Using the tools like Genetic Algorithms, Simulated Annealing, and Tabu search methods for optimization.
- Applying the mathematical results, search methods and numerical techniques for optimization using the one dimensional minimization methods.
- Apply optimization knowledge for minimal cost and minimal weight.

**Laboratory Component**

The student will be able to

- To know the by Optimization Techniques implementing visiting industry.
- Learn the concepts of Direct search methods and one dimensional minimization methods for minimal cost and minimal weight
- Conducting a mini project in Optimization Techniques to solve realistic engineering problems.

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | **Explain**the Engineering application of optimization, Statement of optimization problem, Classification of optimization problems | L2 |
| CO2 | **Evaluating** theUnimodal function, unrestricted search, Exhaustive search, Dichotomous search | L3 |
| CO3 | **Evaluating** the Direct search methods- Univariate method, Hook and Jeeves' method, Powell's method, Simplex method. | L3 |
| CO4 | **Explain** the Desirable and undesirable effects – functional requirement material and geometrical parameters. | L2 |
| CO5 | **Analysing** the Optimization Techniques by visiting implemented industry. | L5 |
| CO6 | **Evaluating** and conducting a mini project to solve realistic engineering problems on Optimization Techniques | L3 |

**Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Engineering application of optimization** | 08 Hours |
| | Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, single variable optimization, and Multivariable optimization with no constraints. Multivariable optimization with equality constraints and inequality constraints, Kuhn - Tucker conditions. | |
| | | |
| **Unit-2** | **One - dimensional minimization methods-** | 06 Hours |
| | One - dimensional minimization methods- Unimodal function, unrestricted search, Exhaustrive search, Dichotomous search, Fibonacci method, Golden section method. Quadratic, Cubic interpolation methods. | |
| | | |
| **Unit-3** | **Direct search methods-** | 08 Hours |

| | | |
|---|---|---|
| | Direct search methods- Univariate method, Hook and Jeeves' method, Powell's method, Simplex method. Descent Methods- Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method.<br>Genetic Algorithms - Simulated Annealing - Tabu search methods. | |
| | | |
| **Unit-4** | **Desirable and undesirable effects** | 06 Hours |
| | Desirable and undesirable effects – functional requirement – material and geometrical parameters – Design of simple axial, transverse loaded members for minimum cost and minimum weight. | |
| | | |
| | **Total =** | **28 Hours** |

**2.4 Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Optimization Techniques process tools One - dimensional minimization methods , | 7 Hours |
| Experiment 2 | Optimization Techniques process tools Direct search methods, | 7 Hours |
| Experiment 3 | Optimization Techniques process tools Genetic Algorithms, | 7 Hours |
| Experiment 4 | Simulated Annealing ,Tabu search methods are implemented to minimum cost and minimum weight. | 7 Hours |
| | Open-ended Project (With Industrial Collaboration based on relevance) | 28 ours |
| | | **50 Hours** |

**2.5 Text Book and References**

| | |
|---|---|
| **Text Books:** | |

1. Rao, S. S., Optimisation - Theory and Application, Wiley Eastern, 1979.
2. Deb, K., Optimization for Engineering Design -Algorithms and Examples, Prentice-Hall India, 1995

| | |
|---|---|
| **Reference Books:** | |

1. Arora, J. S., Introduction to Optimum Design, Mc Graw-Hill, 1989.
2. Reklaitis, G. V., Ravindran, A. and Ragsdell, K. M., Engineering Optimization-Methods and Applications, Wiley, 1983.

**Course: RELIABILITY AND FAILURE ANALYSIS**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech. programme** |
| Specialization | **Design Engineering** |
| Course Title | **RELIABILITY AND FAILURE ANALYSIS** |
| Course Code | **20MDE5051** |
| Semester | **II Semester** |

**1. Course Size and Instruction Method**

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project(With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

**2. Course Details**

**2.1 Course Aim and Summary**

The basic scope of this course is to understand various types of failure modes in engineering materials, contributing factors to those failures and analysis and detection methods employed in the relevant industries. The failure of engineering materials under discussion includes those by mechanical, electrical and chemical load. Specific cases of discussion include materials for structural as well as microelectronics applications. Also discussed will be the method of statistical analysis and its modeling.

**2.2 Course Objectives**

**Theory Component:**

- To understand the course and is planned for those interested in reliability and failure analysis of experiments.
- To allows and increase efficiency of experimentation, and reveal the essential reliability nature of a process.
- In particular, risk analysis and techniques are learnt more.

**Laboratory Component:**

- Gain knowledge on reliability assessments and failure analysis studies of electronic components and systems.
- Study the failure analysis using Fusion 360 and Ansys.

**2.3 Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | **Understand** the basics of fracture mechanics. | L2 |
| CO2 | **Study** the failure caused by corrosion. | L2 |
| CO3 | **Analyse**failures by interface reaction and diffusion process. | L3 |
| CO4 | **Determine** statistical analysis techniques | L3 |
| CO5 | **Detect**how failure are modeled | L3 |

**2.4 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction** | 06 Hours |
| | Need and scope of failure analysis and preventionQuality and Reliability, Industry practices of FA and reliability engineering, Common failure types. | |
| | | |
| **Unit-2** | **Mechanical Fracture, Reaction and Diffusion Induced** | 06 Hours |
| | Time Varying Reliability Analysis, NDT for failure analysis, Destructive testing, Fracture mechanics, Fatigue, Delamination.Electromigration, Thermomigration. | |
| | | |
| **Unit-3** | **Corrosion Induced Failure** | 06 Hours |
| | General wear, Galvanic corrosion, Stress Corrosion Cracking. Industrial engineering tools for failure analysis: Fishbone diagram. | |
| | | |
| **Unit-4** | **Statistical Analysis of Failure** | 05 Hours |
| | Basics of statistics, Normal, Weibull and log-normal distribution, Statistical modeling of failure. Industrial engineering tools for failure analysis: Reliability | |
| | | |
| **Unit-5** | **Examples of failure analysis** | 05 Hours |
| | Electromigration in IC devices, fatigue analysis of solder joints for IC package, Case of twin-tower. | |
| | **Total =** | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Modeling of lap joint | **28 Hours** |
| Experiment 2 | Modeling of butt joint | |

| | | |
|---|---|---|
| Experiment 3 | Failure analysis of lap joint | |
| Experiment 4 | Failure analysis of butt joint | |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | **28 Hours** |
| | Total | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**

1. Modarres, Reliability and Risk analysis, Mara Dekker Inc., 1993
2. New Juran, J.M and Gryna, F.M,
3. Quality Planning and Analysis - Tata Mc Graw Hill publishing Company Ltd. 1982, Delhi, India.

**Reference Books:**

1. Halpern, Seigmund, The Assurances Sciences, Prentice Hall International, New Jersey, U.S.A. 1978
2. Blanchard, Bejamin S. Logistics Engineering and Management, Prentice Hall International, New Jersey, U.S.A. 1986.

**Course: Advanced Mechanical Vibrations**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Advanced Mechanical Vibrations** |
| Course Code | **20MDE5052** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **4** | **2** | **-** | **2** | **6** |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Theory Component | 2x14 | 28 Hours |
| Lab Component | 2x14 | 28 Hours |
| Open-ended Project (With Industrial Collaboration based on relevance) | 2x14 | 28 Hours |
| | **Total** | **84 Hours** |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course will equip students with the necessary knowledge to use principles of physics to mathematically model mechanical systems. The students will be exposed to designing of vibration isolators and absorbers. Students will also gain hands-on experience in using finite element analysis software ANSYS for modal analysis on continuous systems.

### 2.2 Course Objectives

The objectives of the Course are to:

- Introduce linear and nonlinear vibration analysis of systems.
- Develop mathematical model to represent dynamic system
- Determine the natural frequency of mechanical system
- Formulate continuous system problems and solving them.
- Analyze vibratory response of mechanical system

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Generate a mathematical model for a given mechanical system | L2 |
| CO2 | Design vibration isolator/ absorber for various problem statements | L3 |
| CO3 | Apply the concept of non linearity in mechanical systems | L3 |
| CO4 | Solve random vibrations problems | L3 |
| CO5 | Perform modal analysis of continuous systems | L4 |
| CO6 | Mini Project | L4 |

### 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Review of one degree of freedom free and forced vibrations** | 06 Hours |
| | Transient Vibration of single Degree-of freedom systems- Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation. | |
| | | |
| **Unit-2** | **Vibration Control** | 06 Hours |
| | Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers. Modal analysis & Condition Monitoring, Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. | |
| | | |
| **Unit-3** | **Non-Linear Vibrations** | 06 Hours |
| | Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. | |
| | | |
| **Unit-4** | **Random Vibrations** | 05 Hours |
| | Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. | |
| | | |
| **Unit-5** | **Continuous Systems** | 05 Hours |
| | Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. | |
| **Total =** | | **28 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Determination of natural frequency of SDOF systems. | 6 Hours |
| Experiment 2 | Mathematical modelling of mechanical systems | 6 Hours |
| Experiment 3 | Design of dynamic vibration absorbers | 8 Hours |
| Experiment 4 | Modal analysis | 8 Hours |
| | Open-ended Project<br>(With Industrial Collaboration based on relevance) | 28 Hours |
| | | **56 Hours** |

## 2.5 Text Book and References

**Text Books:**


1. William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, Theory of Vibration with Application, 5th Edition Pearson Education, 2008.
2. Rao, S. S., Mechanical Vibrations, 4th Edition, Pearson Education, 2004.


**Reference Books:**


1. Graham Kelly, S., Mechanical Vibrations, Schaum's Outlines, Tata McGraw Hill, 2007.
2. Sujatha, C, Vibrations and Acoustics - Measurements and signal analysis, Tata McGraw Hill, 2009

**Course: DISSERTATION PHASE-1**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **DISSERTATION PHASE-1** |
| Course Code | **20MDE5302** |
| Semester | **III Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 12 | - | - | 24 | 24 |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. COURSE DETAILS

### 2.1 COURSE OBJECTIVES:

1. To develop the work practice in students to apply theoretical and practical tools/techniques
2. To improve the professional competency
3. To improve research aptitude by touching the areas which otherwise not covered by theory or laboratory classes.
4. To solve real life problems related to industry and current research.

### 2.2 COURSE OUTCOMES:

1. Solving of real time problems not necessarily new line of enquiry, but shows that student has mastered research and synthesizing skills in producing a contribution to knowledge.
2. Builds competency and research aptitude.

The thesis shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed.

**Course: DISSERTATION PHASE-2**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **DISSERTATION PHASE-2** |
| Course Code | **20MDE5402** |
| Semester | **IV Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 12 | - | - | 12 | 12 |

**Mentoring Hours:**
Conduction of Classes: **As per Time Table**

## 2. COURSE DETAILS

### 2.1 COURSE OBJECTIVES:

The dissertation demonstrates the student's mastery of relevant resources and methods.

1. An ordered, critical exposition of knowledge gained through student's own effort.
2. Demonstrates sound under-standing of research process.
3. Demonstrates knowledge of appropriate methodology.
4. Demonstrates ability to present study in a disciplined way in scholarly conventions of the discipline.
5. Ability to make critical use of published work.

### 2.2 COURSE OUTCOMES:

1. Improves the professional competency and research.
2. Develops the work to apply theoretical and practical tools/techniques
3. Solve problems related to industry and current research.
4. Possible publication in journal or conferences.

### 2.3 THE REPORT GENERALLY CONTAINS:

1. Cover
2. Title page
3. Certificate(s)
4. Acknowledgements
5. Abstract
6. Contents page
7. List of figures or Tables
8. Introduction
9. Literature survey
10. Methodology

11. Results and Discussion
12. Conclusion and scope of future work.
13. Reference list / Bibliography
14. Appendices.

**2.4 Avoiding plagiarism**

1. Plagiarism is taking the words, theories, or ideas of another person and passing them off as your own.
2. Plagiarism can be copying inadvertently/advertently a passage from a book or journal or pasting something from the internet into report without referencing the original source.
3. Plagiarism can also result from wrong referencing.

**2.5 Avoiding plagiarism**

The guide/supervisor shall certify that the report is checked for plagiarism and is within 25% of the content.

The thesis shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed. It is expected that students should refer national and international journals, proceedings of national and international seminars. Emphasis should be given to the introduction to the topic, literature review, and scope of the proposed work along with some preliminary work/experimentation carried out on the thesis topic. Student should submit the thesis covering the content discussed above and highlighting the features of work to be carried out in the thesis. Student should follow standard practice of thesis writing. At the end of successfully finishing the work he/she has to submit a detailed report and has to present for a viva–voce.

**Course: SPECIAL TOPICS - I**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M.Tech,** |
| Specialization | **Design Engineering** |
| Course Title | **Special Topics - I (Practice)** |
| Course Code | **20MDE5104** |
| Semester | **I** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| **2** | **-** | **-** | **2** | **4** |

**Total Semester hours: 4x14= 56 Hours**

| | | |
|---|---|---|
| Theory Component | - | - |
| Lab Component | 4x14 | 56 Hours |
| | **Total** | 56 **Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course is aimed at introducing current technologies such as AI & ML, Data Analytics and IOT and the applications of all of these technologies to mechanical engineering.

### 2.2 Course Objectives

The objectives of the Course are:

- To present the fundamental principles and practices of AI , ML, Data Analytics and IOT
- To address the real-world mechanical engineering problems using AI , ML, Data Analytics and IOT
- To develop a basic understanding of these technologies and apply them to solve mechanical domain problems including Automotive, Aerospace and other inter-disciplinary areas.

### 2.3 Course Outcomes

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Recognise the importance of AI & ML, Data sciences & IOT in Mechanical Engineering | |
| CO2 | Comprehend the ideas of AI and problem-solving techniques | |
| CO3 | Apply Machine Learning and Deep Learning algorithms | |
| CO4 | Apply Data Analysis algoritms | |
| CO5 | Apply IOT concepts to mechanical domain problems | |

## 2.4 Course Content

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to New Technologies** | 08 Hours |
| | Introduction to Artificial Intelligence, Machine Learning, Data Analytics & Internet of Things. Application of the Mechanical Domain areas such as Automobile, Aerospace & other inter-disciplinary areas. | |
| | | |
| **Unit-2** | **Machine Learning** | 08 Hours |
| | Introduction to Supervised Learning(Regression and Classificatio), Un-Supervised Learning (Clustering and Assciation), Reinforcement learning and Machine learning Algorithms(Linear Regression, Logistic Regression, Decision Tress, Random Forest, SVM,KNN, K-Means Clustering, Q-Learning) | |
| | | |
| **Unit-3** | **Deep Learning** | 08 Hours |
| | Introduction to Deep Learning and Artificial Neural Network, Deep Neural Network (DNN), Convolution Neural Network (CNN), Recurrent Neural Network (RNN) | |
| | | |
| **Unit-4** | **Data Analytics** | 08 Hours |
| | Introduction to Data Warehousing, Extract, Transform & Load (ETL), SQL & NOSQL | |
| | | |
| **Unit-5** | **Internet of Things** | 08 Hours |
| | Introduction to Computer Networks and ISO, OSI Layers and TCP and IP Protocols.<br>Introduction to Internet of Things, Introduction to Sensors, Actuator, Transducers, Gateway, IOT Architecture, Introduction to Node MCU and Arduino. Application of IOT in Home Mechanical, Aerospace and Automobile Industries. | |
| | **Total =** | **40 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Hands-on training on Python and Machine learning Algorithms using SCIKIT Learn | 04 Hours |
| Experiment 2 | Implementation of Deep Learning Networks using KERAS | 04 Hours |
| Experiment 3 | Implementation of Data Warehousing concepts using PANDAS,SQL | 04 Hours |
| Experiment 4 | IOT lab using Arduino, Node MCU, sensors and Arduino IDE | 04 Hours |
| | | **16 Hours** |

## 2.5 Text Book and References

**Text Books:**


1. Mayur Ramgir, Internet of Things- Architecture, Implementation, and Security [Print Replica] Kindle Edition, Pearson
2. Manohar Swamynathan (Author), Mastering Machine Learning with Python in Six Steps; A Practical Implementation Guide to Predictive Data Analytics Using Python 1st ed, Kindle Edition, Apress.
3. Jojo Moolayil, Learn Keras for Deep Neural Networks: A Fast-Track Approach to Modern

| |
|---|
| Deep Learning with Python 1st ed. Edition, Kindle Edition |

**Reference Books:**


1. David L. Poole, Alan K. Mackworth, Artificial Intelligence: Foundations of Computational Agents, Cambridge University Press, 2010.
2. Nils J. Nilsson, the Quest for Artificial Intelligence, Cambridge University Press, 2009.
3. Richard E Neapolitan; Xia Jiang Artificial Intelligence: With an Introduction to Machine Learning, Chapman and Hall/CRC Press, 2018.
4. Sttuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson E ducation 2007.
5. Nagy Z. Artificial Intelligence and Machine Learning Fundamentals: Develop real world applications powered by the latest AI advances. Packt Publishing Ltd; 2018.

**Course: Special Topics-2**

| | |
|---|---|
| School | **School of Engineering** |
| Department | **Mechanical Engineering** |
| Programme | **M. Tech programme** |
| Specialization | **Design Engineering** |
| Course Title | **Special Topics-2** |
| Course Code | **20MDE5204** |
| Semester | **II Semester** |

## 1. Course Size and Instruction Method

| Credits | L | T | P | Hours/Week |
|---|---|---|---|---|
| 2 | | - | 2 | 4 |

**Total Semester hours: 6x14= 84 Hours**

| | | |
|---|---|---|
| Lab Component | 4x12 | 48 Hours |
| | **Total** | **48 Hours** |

**Mentoring Hours:**

Conduction of Classes: **As per Time Table**

## 2. Course Details

### 2.1 Course Aim and Summary

The course is aimed to learn the basics of block-chain, Virtual reality and augmented reality, Application of cloud computing in mechanical engineering, Basics of Quantum computing and the application of all of these new technologies to mechanical engineering.

### 2.2 Course Objectives

The objectives of the Course are:

1. To provide conceptual understanding of how block chain technology can be used to innovate and improve business processes.
2. Develop and implement algorithm and write programs using these algorithm.
3. To provide a detailed understanding of the concepts of Virtual Reality and its applications.
4. To apply these new technologies to mechanical engineering problems

**Course Outcomes**

**After undergoing this course students will be able to:**

| CO No. | Outcomes | Bloom's Taxonomy Level |
|---|---|---|
| CO1 | Explain block chain technology concepts | L2 |

| | | |
|---|---|---|
| CO2 | Construct VR models using CAD software | L2 |
| CO3 | Demonstrate knowledge on concepts, key technologies, strengths and limitations of cloud computing | L2 |
| CO4 | Explain the working of a Quantum Computing program, its architecture and program model | L2 |
| CO5 | Apply block chain, VR and AR, Cloud computing, Quantum computing to Mechanical engineering | L3 |

**2.3 Course Content**

**Theory Component:**

| | | |
|---|---|---|
| **Unit-1** | **Introduction to Block chain** | 05 Hours |
| | Introduction: Overview of Block chain, Block in a Block chain, Transactions, Distributed Consensus, Public vs Private Block chain, Understanding Crypto currency to Block chain, Overview of Security aspects of Block chain. | |
| | | |
| **Unit-2** | **Virtual Reality (VR), Augmented Reality (AR)** | 05 Hours |
| | Virtual Reality: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality.<br>Augmented Reality: Taxonomy, technology and features of augmented reality, difference between AR and VR, Augmented reality methods. | |
| | | |
| **Unit-3** | **Cloud Computing** | 05 Hours |
| | Introduction to cloud delivery models, Cloud service model architecture. | |
| | | |
| **Unit-4** | **Quantum Computing** | 05 Hours |
| | Introduction to Quantum Computing, Motivation for studying Quantum Computing, Overview of major concepts in Quantum Computing: Qubits and multi-qubits states, Bra-ket notation, Bloch Sphere representation, Quantum Superposition, Quantum Entanglement. | |
| | | |
| **Unit-5** | **Applications in Mechanical engineering** | 04 Hours |
| | Study few current journal papers | |
| | **Total =** | **24 Hours** |

**Laboratory Component:**

| | | |
|---|---|---|
| Experiment 1 | Learning Algorithms related to Block Chain and applications to simple problems | 08 Hours |
| Experiment 2 | Carry out assembly/disassembly of an engine using Virtual Reality | 08 Hours |
| Experiment 3 | Applications of Cloud Computing on Mechanical Engineering | 08 Hours |
| | | **24 Hours** |

## 2.4 Text Book and References

| **Text Books:** | |
|---|---|


1. Daniel Drescher, "Block Chain Basics", Apress; 1stedition, 2017
2. Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
3. William R. Sherman, Alan B. Craig, "Understanding Virtual Reality: Interface, Application and Design", Morgan Kaufmann, 2008.
4. Cloud Computing by Lizhe Wang, Rajiv Ranjan, Jinjun Chen, Boualem Benatallah Released December 2017 Publisher(s): CRC Press ISBN: 9781351833097.


| **Reference Books:** | |
|---|---|


1. Block chain Revolution: How the Technology behind Bitcoin and Other Cryptocurrencies is changing the World by Don Tapscott, Alex Tapscott.
2. David McMahon, "Quantum Computing Explained", Wiley
3. John Vince, "Virtual Reality Systems ", Pearson Education Asia, 2007.