**Zeal Education Society's**

# ZEAL COLLEGE OF ENGINEERING & RESEARCH, PUNE – 41

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

*NAAC Accredited with **A+** Grade / ISO 21001:2018*

## DEPARTMENT OF MECHANICAL ENGINEERING

## Curriculum Structure and Syllabus of

## F.Y. M. Tech. - Mechanical Engineering

# Design Engineering

## (With effect from - Academic Year 2024- 25)

## VISION OF THE INSTITUTE

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude**.**

## MISSION OF THE INSTITUTE

- To achieve academic excellence through innovative teaching and learning process.
- To imbibe the research culture for addressing industry and societal needs.
- To inculcate social attitude through community engagement initiatives.
- To provide conducive environment for building the entrepreneurial skills.

# DEPARTMENT OF MECHANICAL ENGINEERING

## VISION:

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude.

## MISSION:

**M1:** To achieve academic excellence through innovative teaching and learning process.
**M2:** To imbibe the research culture for addressing industry and societal needs.
**M3:** To inculcate social attitude through community engagement initiatives.
**M4:** To provide conducive environment for building the entrepreneurial skills.

## PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

**PEO1:** To produce post-graduate engineers to participate in innovative and integrative activities desired for modern design engineering by developing their competencies and contemporary technical skills.
**PEO2:** To make post-graduate engineers proficient in contributing at a level of research and development in the fields of advanced engineering design of mechanical engineering systems.
**PEO3:** To make post-graduate engineers develop life skills to become professional design engineers, administrators, or academicians and engage in lifelong learning by adopting techno-social developments of the nation.

## PROGRAM OUTCOMES (POs):

**PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.
**PO2:** An ability to write and present a substantial technical report/document.
**PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

## PROGRAM SPECIFIC OUTCOMES (PSOs):

**PSO1:** Apply knowledge of design engineering for development of effective and innovative solutions to engineering problems.
**PSO2:** Apply appropriate methodology, contemporary hardware and software tools to solve complex engineering problems in the domain of design engineering.

# DEPARTMENT OF MECHANICAL ENGINEERING

## LIST OF ABBREVIATIONS

| Abbreviation | Description |
|---|---|
| PCC | Programme Core Course |
| PEC | Programme Elective Course |
| MDM | Multidisciplinary Minor |
| OE | Open Elective - Other than a particular program |
| VSEC | Vocational and Skill Enhancement Course |
| MC | Management Courses |
| DIS | Dissertation Phase |
| MOOC | Massive Open Online Course -I |
| M. Tech. | Master of Technology |
| L | Lecture |
| P | Practical |
| T | Tutorial |
| H | Hours |
| CR | Credits |
| CIE | Continuous Internal Evaluation |
| ETE | End Term Examination |
| TH | Theory |
| TW | Term Work |
| OR | Oral |
| PR | Practical |

# DEPARTMENT OF MECHANICAL ENGINEERING

## First Year M. Tech. – Design Engineering: Semester - I

| Course Code | Course Type | Course Name | Teaching Scheme (hrs/Week) | | | | | | Evaluation Scheme (Marks) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | P | H | CR | | | CIE | ETE | TW | PR | OR | Total |
| | | | | | | TH | PR | Total | | | | | | |
| MEDE101 | PCC | Applied Mathematics | 4 | - | 4 | 4 | - | 4 | 50 | 50 | - | - | - | 100 |
| MEDE102 | PCC | Advanced Stress Analysis | 4 | - | 4 | 4 | - | 4 | 50 | 50 | - | - | - | 100 |
| MEDE103 | PCC | Analysis and Synthesis of Mechanisms | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | - | 100 |
| MEDE104 | PEC | Program Elective – I* | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | | 100 |
| | OEC | Open Elective – I# | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | - | 100 |
| MEDE106 | LC | Numerical Simulation Lab | - | 2 | 2 | - | 1 | 1 | - | - | 25 | 25 | - | 50 |
| MEDE107 | LC | Design Engineering Lab-I | - | 2 | 2 | - | 1 | 1 | - | - | 25 | - | 25 | 50 |
| MEDE108 | SEM | Seminar | - | 2 | 2 | - | 1 | 1 | - | - | 25 | - | 25 | 50 |
| MEDE109 | MC | Audit Course – I: Technical Paper writing | 1 | - | 1 | - | - | - | - | - | - | - | - | - |
| **Total** | | | **18** | **6** | **24** | **17** | **3** | **20** | **250** | **250** | **75** | **25** | **50** | **650** |

*** Program Elective – I: Choose any one from the following:**

| Course Code | Course Type | Program Elective-I |
|---|---|---|
| MEDE104A | PEC | Engineering Optimization Techniques |
| MEDE104B | | Industrial Tribology |

**# Open Elective – I: Choose any one from the following:**

| Course Code | Course Type | Open Elective – I | Offered by Department |
|---|---|---|---|
| CODS105 | OEC | Cloud Computing for Data Science | Computer |
| EEPS105 | | Industrial Automation | Electrical |
| ETIS105 | | Internet of Things | E&TC |
| MERA105 | | Microcontrollers Architecture and Programming | Mechanical |

BoS Chairman

ZES's Zeal College of Engineering & Research PU/PN/Engg./285/2007 Narhe, Pune-41

Director
ZES's Zeal College of Engineering & Research Narhe, Pune - 411041.

# DEPARTMENT OF MECHANICAL ENGINEERING

## First Year M. Tech. – Design Engineering: Semester - II

| Course Code | Course Type | Course Name | Teaching Scheme (hrs/Week) | | | | | | Evaluation Scheme (Marks) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | P | H | CR | | | CIE | ETE | TW | PR | OR | Total |
| | | | | | | TH | PR | Total | | | | | | |
| MEDE201 | PCC | Advanced Mechanical Vibrations & Acoustics | 4 | - | 4 | 4 | - | 4 | 50 | 50 | - | - | - | 100 |
| MEDE202 | PCC | Research Methodology and Intellectual Property Rights | 4 | - | 4 | 4 | - | 4 | 50 | 50 | - | - | - | 100 |
| MEDE203 | PCC | Finite Element Method | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | - | 100 |
| MEDE204 | PEC | Program Elective – II* | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | | 100 |
| | OEC | Open Elective – II# | 3 | - | 3 | 3 | - | 3 | 50 | 50 | - | - | - | 100 |
| MEDE206 | LC | Program Elective Lab-I | - | 2 | 2 | - | 1 | 1 | - | - | 25 | 25 | - | 50 |
| MEDE207 | LC | Design Engineering Lab-II | - | 2 | 2 | - | 1 | 1 | - | - | 25 | - | 25 | 50 |
| MEDE208 | DIS | Dissertation Phase - I | - | 2 | 2 | - | 1 | 1 | - | - | 25 | - | 25 | 50 |
| MEDE209 | MC | Audit Course - II : Constitution of India | 1 | - | 1 | - | - | - | - | - | - | - | - | - |
| **Total** | | | **18** | **6** | **24** | **17** | **3** | **20** | **250** | **250** | **75** | **25** | **50** | **650** |

*** Program Elective – I: Choose any one from the following:**

| Course Code | Course Type | Program Elective - II |
|---|---|---|
| MEDE204A | PEC | Advanced Machine Design |
| MEDE204B | | Fatigue and Fracture Analysis |

**# Open Elective – II: Choose any one from the following:**

| Course Code | Course Type | Open Elective – II | Offered by Department |
|---|---|---|---|
| CODS205 | OEC | IoT and Sensor Data Analysis | Computer |
| EEPS205 | | Electric Vehicles | Electrical |
| ETIS205 | | Embedded System | E&TC |
| MERA205 | | Micro Electro Mechanical Systems | Mechanical |

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# DEPARTMENT OF MECHANICAL ENGINEERING

## INDEX

## DEPARTMENT OF MECHANICAL ENGINEERING

# SYLLABUS

## SEMESTER - I

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Applied Mathematics | | | | | | | | **Code:** MEDE101 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 04 | - | - | 04 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

1. The students should have good knowledge of set theory, probability, and basic Numerical Techniques.
2. The students should clear understanding of Engineering Mathematics-I, II, and III

**Course Objectives:**

1. To find the roots of polynomials in Science and Engineering problems.
2. To differentiate and integrate a function for a given set of tabulated data, for engineering applications.
3. To understand Eigen values and Eigen Vectors to maintain relationships between two variables while solving problems.
4. To explore the techniques of linear algebra.
5. To apply various mathematical methods involving arithmetic and algebra to solve problems.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the basic concepts of linear algebra, numerical methods, and probability distribution |
| **CO2** | Apply the concept of linear algebra, numerical methods, and probability distribution to solve the problems arising in the Engineering field |
| **CO3** | Analyze mathematical problems arising in Engineering, using the concepts of linear algebra |
| **CO4** | Apply the mathematical knowledge of numerical methods, and probability distribution in the Engineering field. |
| **CO5** | Presentation of application of Mathematics in Engineering Domain |
| **CO6** | Understand the basic concept of statistical models |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Roots of Polynomial and Transcendental Equation:** Solving algebraic equation: Newton-Raphson method, Secant method. Multiple roots, Simple fixed-point iteration. |
| 2. | **Numerical Differentiation and Integration:** Numerical Differentiation for equal width and Numerical Integration: Newton – Cotes and Gauss Quadrature Integration formulae (Simpson 1/3 rule), Romberg integration, Numerical differentiation (equal width only) Applied to engineering problems, High accuracy differentiation formulae |
| 3. | **System of Linear Algebraic Equations and Eigen Value- vector Problems:** Gauss elimination method, Gauss-Jordan elimination method, Triangularization method, |

| | |
|---|---|
| | Cholesky method, Partition method, Iteration methods. Bounds on Eigen values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method. |
| 4. | **Probability Distribution and Sampling Theory:** Discrete probability distribution and statistical value. Poisson's process. Normal distribution. Chi-square test for goodness of fit test (Poisson's, uniform, proportion). |
| 5. | **Linear Transformation:** Introduction to Linear transformation, the matrix of linear transformation, Orthogonality using G-S method, Least Squares, SVD. |
| 6. | **Statistical Models:** Regression; Cluster analysis, Principal component analysis. |

**Text Books:**

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

**Reference Books:**

1. Pervez Moin, "Fundamentals of Engineering Numerical Analysis", Cambridge, 2010.
2. David C. Lay, "Linear Algebra and its Applications", 3rd edition, Pearson Education, 2002.
3. S.S. Sastry, "Introductory Methods of Numerical Analysis", PHI, 2005.
4. Gilbert Strang, "Linear Algebra", Cengage India Private Limited, 4th edition.
5. David C. Lay, "Linear Algebra and its Applications", 3rd edition, Pearson Education, 2002.

**E-Resources:**

1. NPTEL course on Numerical Methods in Civil Engineering by Dr. A. Deb, IIT Kharagpur https://nptel.ac.in/courses/105105043
2. Coursera course on Numerical Methods for Engineers by Jeffrey R. Chasnov https://www.coursera.org/learn/numerical-methods-engineers

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Advanced Stress Analysis | | | | | | | | | **Code:** MEDE102 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 04 | - | - | 04 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Strength of Materials, Design of machine elements

**Course Objectives:** At the end of the course, the student will be able to -

1. To understand the concept of three-dimensional stress and strain at a point.
2. To understand stress distribution in components subjected to unsymmetrical bending and torsional loading.
3. To study methods of computing contact stresses and deflections
4. To study different techniques of experimental stress analysis

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Determine stress distribution along a component under different loading conditions. |
| **CO2** | Understand the behavior of walled sections. |
| **CO3** | Solve real-time problems subjected to bending. |
| **CO4** | Analyze failure modes and phenomena in two and three-dimensional stresses of composite material. |
| **CO5** | Understand the concept of contact stresses in mechanical component. |
| **CO6** | Apply the knowledge of the Experimental Stress Analysis. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Theory of Elasticity:** Theory of Elasticity problems in two dimensions - stress strain relationship for brittle materials, ductile materials. Compatibility equations in two and three dimensions, free body diagram of complicated structures and stress calculations, stress functions in rectangular and cylindrical coordinate systems. |
| 2. | **Theory of Torsion:** Theory of Torsion Torsion of general prismatic bars of solid section, Membrane Analogy, Torsion of Thin walled tubes, Torsion of Thin walled Multiple-Cell closed sections, Torsion of rolled Sections. |
| 3. | **Bending And Shear Centre:** Concept of shear center in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear center for thin wall beam cross section, an open section with one axis of symmetry, general open section, and closed section. |
| 4. | **Stress Analysis of Engineering Plastics and Composites:** Types of engineering plastics (Nylon, ABS, PP) failure modes, failure phenomenon in two and |

| | |
|---|---|
| | three-dimensional stress analysis, wear and tear of plastics, impact properties of plastics, types of composites, evaluation of elastic properties of composites. |
| 5. | **Contact Stresses:**<br>Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts. |
| 6. | **Experimental Stress Analysis:**<br>Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement.<br>Theory of photo-elasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns. |

**Text Books:**

1. Timoshenko and Goodier, "Theory of Elasticity", McGraw-Hill.
2. Richard G. Budynas, "Advanced Strength and Applied Stress Analysis", McGraw-Hill.
3. Boresi, Schmidt, and Sidebottom, "Advanced Mechanics of Materials", John Wiley & Sons.

**Reference Books:**

1. Cook and Young, "Advanced Mechanics of Materials", Prentice Hall.
2. L.S. Shrinath, "Advanced Mechanics of Solids", Tata McGraw-Hill.
3. S. Timoshenko, "Advanced Strength of Materials", Vol. 1, CBS.
4. Den Hartog, "Advanced Strength of Materials", Dover Publications Inc.
5. James W. Dally and William F. Riley, "Experimental Stress Analysis", McGraw Hill Education.
6. E.J. Hern, "Mechanics of Materials", Butterworth-Heinemann Publisher.
7. Andrew Singer and Ferdinand L. Singer, "Strength of Materials", Longman Publisher.

**E-Resources:**

1. NPTEL course on Experimental Stress Analysis, by Prof. K. Ramesh, IIT Madras
   https://nptel.ac.in/courses/112106068

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Analysis and Synthesis of Mechanisms | | | | | | | | | **Code:** MEDE103 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Mechanical Engineering Fundamentals, Mathematical Methods for Engineering, Introduction to Kinematics and Dynamics.

**Course Objectives:**

1. To understand fundamental concepts in mechanisms and kinematics.
2. To study kinematic analysis techniques for planar mechanisms.
3. To explore kinematics analysis of complex mechanisms.
4. To know the importance of curvature theory and its applications.
5. To synthesize planar mechanisms analytically and graphically.
6. To apply graphical synthesis techniques to mechanism design.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the fundamentals of mechanism and kinematic principles. |
| **CO2** | Apply advanced kinematic analysis techniques to complex mechanisms. |
| **CO3** | Utilize curvature theory in mechanism design and analysis. |
| **CO4** | Synthesize planar mechanisms using analytical methods. |
| **CO5** | Implement graphical synthesis techniques for mechanism design. |
| **CO6** | Perform advanced kinematic analysis of spatial mechanisms. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Kinematics Analysis of Planer Mechanisms:** Introduction to Mechanisms and Kinematics, planar and spatial mechanisms; degree of freedom, Grashoff's and Grubler's criteria, equivalent linkages, Mechanical advantage and transmission angle, Kinematic analysis of planer mechanisms |
| 2. | **Kinematics Analysis of Complex Mechanisms:** Complex Mechanisms Types of complex Mechanisms, velocity-acceleration analysis of complex mechanisms by the Normal Acceleration method and Auxiliary Point Method, Introduction to Goodman's Method. |
| 3. | **Curvature theory:** Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature, Ball's point, and applications in dwell mechanisms. |
| 4. | **Analytical Synthesis of planar mechanisms:** Synthesis for four accuracy points, compatibility condition, Introduction to complex numbers method of synthesis, the dyad, centre point and circle point circles, ground pivot specifications. |

| | |
|---|---|
| 5. | **Graphical Synthesis of planar mechanisms:**<br>Graphical synthesis for function generation and rigid body guidance with two and three accuracy points using Relative pole method & Inversion method, center point and circle point curves. |
| 6. | **Kinematics of Spatial Mechanisms:**<br>Kinematic Analysis of Spatial Mechanisms, Denavit-Hartenberg parameters, Velocity and acceleration analysis of spatial linkages. |

**Text Books:**

1. Arthur Erdman, George Sandor, Sridhar Kota, "Mechanism Design" Analysis and Synthesis, 21 June 2001.
2. Michael M. Stanisic, Mechanisms and Machines : Kinematics, Dynamics and Synthesis.
3. Michael J. Rider, Design and Analysis of Mechanisms: A Planar Approach.

**Reference Books:**

1. Ghosh and A. K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press.
2. R. S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill.
3. A. G. Erdman and G. N. Sandor, "Mechanism Design - Analysis and Synthesis" (Vol. 1 and 2), Prentice Hall.
4. J. E. Shigley and J. J. Uicker, "Theory of Machines and Mechanisms", 2nd Ed., McGraw-Hill.
5. Robert L. Norton, "Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines", Tata McGraw-Hill, 3rd Edition.
6. A. S. Hall, "Kinematics and Linkage Design", Prentice Hall of India.

**E-Resources:**

1. NPTEL course on Kinematics of Mechanisms and Machines, By Prof. Anirvan DasGupta, IIT Kharagpur. https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-me08/

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Program Elective – I (Engineering Optimization Techniques) | | | | | | | | **Code:** MEDE104A | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

The course is required the Mathematical Foundations and Engineering Analysis regarding Optimization Techniques.

**Course Objectives:**

1. To impart knowledge on theory of optimization and conditions for optimality for unconstraint and constraint optimization problems.
2. To Inculcate modeling skills necessary to describe and formulate optimization problems in design and manufacturing
3. Familiarize with the working principle of optimization algorithms used to solve linear and non-linear problems

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Comprehend the techniques and applications of Engineering optimization. |
| **CO2** | Apply basic concepts of mathematics to formulate an optimization problem. |
| **CO3** | Apply the Classical optimization techniques for engineering applications. |
| **CO4** | Analyze characteristics of a general linear programming problem. |
| **CO5** | Analyze characteristics of a general Nonlinear programming problem. |
| **CO6** | Analyze and appreciate variety of performance measures for various optimization problems. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Introduction to Optimization:** Engineering application of Optimization, Statement of an Optimization problem, Optimal Problem formulation, and Classification of Optimization problem. Optimum design concepts: Definition of Global and Local optima, Optimality criteria, Review of basic calculus concepts, Global optimality. |
| 2. | **Introduction to Mathematical Modeling:** Introduction to Mathematical Modeling, Types of Modeling. Objective function, Constraints and Constraint surface; Mathematical modeling characteristics and limitations, Formulation of design problems. |
| 3. | **Classical Optimization Techniques:** Engineering applications of optimization, classification of optimization problem, single variable optimization, multi variable optimization with no constraint, equality constraint, in-equality constraint. |
| 4. | **Linear Programming:** Standard form of Linear programming (LP), Statement and graphical solution of LP problem, Simplex algorithm, two phases of the simplex method, Primal-dual simplex method, Sensitivity or post optimality analysis, applications in engineering |

| | |
|---|---|
| 5. | **Non-Linear Programming:**<br>One-dimensional minimization - exhaustive search, golden section method, quasi-newton method, random search methods, Powell's method. |
| 6. | **Modern Methods of Optimization:**<br>Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Teaching Learning Based Optimization, Introduction to ANN. |

**Text Books:**

1. J.S. Arora, "Introduction to Optimum Design", Elsevier.
2. E.K. P. Chong and S.H. Zak, "An Introduction to Optimization", Wiley.
3. D. E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley Longman Publishing, 1989.
4. R. Saravanan, "Manufacturing Optimization through Intelligent Techniques", Taylor & Francis Publications, 2006.

**Reference Books:**

1. Raphael T. Haftka and Zafer Gurdal, "Structural Optimization", Kluwer Academic Publishers.
2. M. Asghar Bhatti, "Practical Optimization Methods with Mathematical Applications", Springer.
3. M. P. Bendse and Q. Sigmund, "Topology Optimization – Theory, Methods and Applications".
4. X. Huang and Y.M. Xie, "Evolutionary Topology Optimization of Continuum Structures: Methods and Applications", Wiley, 2010.
5. Singiresu S. Rao, "Engineering Optimization: Theory and Practice", John Wiley & Sons.
6. J.N. Kapur, "Mathematical Modelling", New Age International Publication.
7. K. Deb, "Optimization for Engineering Design", PHI.
8. Belegundu and Chandrupatla, "Optimization Concepts and Applications in Engineering", Pearson Education.

**E-Resources:**

1. NPTEL Course on Optimization, IIT Kharagpur, Prof. A. Goswami, Dr. Debjani Chakraborty https://nptel.ac.in/courses/111105039
2. NPTEL Course on Introduction to Mathematical Modeling, IIT Roorkee, Dr. Ameya Nayak http://www.digimat.in/nptel/courses/video/111107113/L01.html

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Program Elective – I (Industrial Tribology) | | | | | | | | | **Code:** MEDE104B |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Students should aware about the Basic Mechanical Engineering Principles, Introduction to Material Science, Fundamentals of Fluid Mechanics.

**Course Objectives:**

1. To understand the basics of tribology.
2. To analyze friction mechanisms.
3. To evaluate wear mechanisms.
4. To explore lubrication principles.
5. To examine advanced lubrication techniques.
6. To apply surface engineering and tribological design.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understanding of the fundamental concepts, different types of friction and wear mechanisms in tribological systems |
| **CO2** | Select lubricants to suggest a tribological solution to a particular situation |
| **CO3** | Analyze load carrying capacity and flow requirements for hydrostatic step bearings. |
| **CO4** | Analyze the characteristics and applications of different types of gas lubricants, including their flow analysis in lubrication systems. |
| **CO5** | Select different surface modification techniques and their effects on tribological performance. |
| **CO6** | Analyze real-world case studies of tribological failures and identify strategies for prevention and mitigation |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Fundamentals of Tribology, Friction and Wear in Tribology:**<br>Introduction to tribology, Tribology in Design, Economic Importance of Tribology.<br>**Friction:** Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction. Stick-slip friction behavior.<br>**Wear:** Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. |
| 2. | **Lubrication Principles:**<br>Lubrication regimes: boundary, mixed, and hydrodynamic lubrication, Properties of lubricants, Standards of Lubricants, Lubricant additives and their functions: anti-wear, extreme pressure, viscosity modifiers, Modes of Lubrication, Selection criteria for lubricants, Different lubricant analysis methods and performance testing of lubricants. |

| | |
|---|---|
| 3. | **Hydrostatic and Hydrodynamics Lubrication:**<br>Introduction, Hydrostatic Lubrication, Load carrying capacity and flow requirement for hydrostatic step bearings, Optimum design for hydrostatic step bearings, Idealized Hydrodynamic Bearings. Finite Bearings, Oil Flow and Thermal equilibrium, Bearing Design, Squeeze Film bearings, Hydrodynamic Instability. Externally pressurized Oil Bearings. |
| 4. | **Elastohydrodynamics and Gas Lubrication:**<br>Elastohydrodynamic Lubrication, Surface Roughness Effect on Hydrodynamic Bearings and Ball Bearings, Roller Bearings.<br>Gas Lubrication: Introductions, Types of gas lubricants, Types of gas lubricants, Analysis of gas flow in lubrication systems, Applications of gas lubrication in industrial machinery, Merits and Demerits, Applications. |
| 5. | **Surface Engineering for Tribological Applications:**<br>Surface modification techniques: coatings, plating, and surface texturing, Surface characterization methods: profilometry, microscopy, and surface roughness measurement, Tribological performance of engineered surfaces: wear resistance, friction reduction, Applications of surface engineering in industry: automotive, aerospace, manufacturing, and energy sectors |
| 6. | **Tribology in Design Engineering:**<br>Integration of tribological principles in product design: materials selection, surface treatment, and lubrication strategies, Case studies on tribological failures in engineering systems: bearings, gears, seals, and sliding interfaces, Design optimization for improved tribological performance: reliability, durability, and energy efficiency considerations, Emerging trends and future directions in industrial tribology: Nano tribology, bio-inspired lubrication. |

**Text Books:**

1. G. W. Stachowiak and A. W. Batchelor, "Engineering Tribology".
2. B. C. Majumdar, "Introduction to Tribology of Bearings", A. H. Wheeler & Co. Ltd., New Delhi, 1999.
3. Ian M. Hutchings, "Tribology: Friction and Wear of Engineering Materials".

**Reference Books:**

1. Bhushan, B., "Introduction to Tribology." John Wiley & Sons.
2. Jones, A. R., "Tribology: Friction, Wear, and Lubrication." CRC Press.
3. Pinkus, O. and Sternlicht, B., "Theory of Hydrodynamic Lubrication." McGraw-Hill Book Co. Inc., New York.
4. Heshmat, H., "Gas Lubricated Bearings: Fundamentals, Design, Modeling and Applications." Springer.

**E-Resources:**

1. MIT OpenCourseWare: Introduction to Tribology
   Lecture Notes | Tribology | Mechanical Engineering | MIT OpenCourseWare
2. Coursera: Tribology and Mechanical Components
3. NPTEL: Fundamentals of Tribology NPTEL :: Mechanical Engineering - Tribology

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Computer – Data Science) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – I (Cloud Computing for Data Science) | | | | | | | | **Code:** CODS105 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

1. Basic understanding of data science concepts.
2. Familiarity with programming languages like Python or Java.
3. Knowledge of database management systems.
4. Basic understanding of distributed computing.

**Course Objectives:**

1. To understand the fundamentals of cloud computing and its relevance to data science.
2. To gain knowledge on various cloud service models and deployment strategies.
3. To explore cloud storage and computing solutions for data-intensive applications.
4. To learn about the architecture and implementation of big data solutions on cloud platforms.
5. To develop skills for deploying, managing, and scaling data science applications in the cloud.
6. To evaluate the security, privacy, and compliance issues in cloud environments.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the basic concepts and evolution of cloud computing. |
| **CO2** | Identify key cloud services and their applications in data science. |
| **CO3** | Evaluate various cloud storage solutions for data science. |
| **CO4** | Implement big data analytics using cloud services. |
| **CO5** | Implement security best practices for cloud-based data science applications. |
| **CO6** | Explore cloud monitoring and management tools. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Introduction to Cloud Computing:** Definition and characteristics of cloud computing, History and evolution of cloud computing, Cloud service models: IaaS, PaaS, SaaS, Cloud deployment models: Public, Private, Hybrid, and Community. |
| 2. | **Cloud Infrastructure and Services:** Cloud infrastructure components: data centers, networks, storage, Virtualization: concepts, types, hypervisors, Cloud services: compute, storage, networking, database services, Cloud service providers: AWS, Azure, Google Cloud. |
| 3. | **Cloud Storage Solutions:** Cloud storage types: object storage, block storage, file storage, Cloud storage services: Amazon S3, Azure Blob Storage, Google Cloud Storage, Data lifecycle management in the cloud, Case studies and best practices for cloud storage. |

| | |
|---|---|
| 4. | **Cloud Computing for Big Data:**<br>Introduction to big data and cloud computing, Big data processing frameworks: Hadoop, Spark, Cloud-based big data services: Amazon EMR, Google Dataproc, Azure HDInsight, Data ingestion, processing, and visualization in the cloud |
| 5. | **Cloud Security and Privacy:**<br>Security challenges in cloud computing, Cloud security mechanisms: encryption, identity management, access control, Data privacy and compliance: GDPR, HIPAA, Best practices for securing cloud applications |
| 6. | **Managing and Scaling Cloud Applications:**<br>Cloud application lifecycle management, Monitoring and management tools: CloudWatch, Azure Monitor, Google Stackdriver, Auto-scaling and load balancing, Cost management and optimization in the cloud |

**Text Books:**

1. Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall.
2. Xiaolin Li, Jianxin (Jason) Wu, and Adam Li, "Cloud Computing for Data-Intensive Applications", Springer.

**Reference Books:**

1. Rajkumar Buyya, Christian Vecchiola, and S. Thamarai Selvi, "Mastering Cloud Computing: Foundations and Applications Programming", McGraw-Hill Education.
2. Arshdeep Bahga and Vijay Madisetti, "Cloud Computing: A Hands-On Approach", VPT.
3. Nir Kshetri, "Big Data and Cloud Computing for Development: Lessons from Key Industries and Economies in the Global South", Springer.

**E-Resources:**

1. AWS Training and Certification: [AWS Training] https://aws.amazon.com/training/
2. Microsoft Learn: [Azure Training] https://learn.microsoft.com/en-us/training/
3. Google Cloud Training: [Google Cloud raining] https://cloud.google.com/training
4. Coursera: Cloud Computing Specializations and Courses [Coursera] https://www.coursera.org/browse/information-technology/cloud-computing
5. edX: Cloud Computing Courses [edX] https://www.edx.org/learn/cloud-computing

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Electrical – Power Systems) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – I (Industrial Automation) | | | | | | | | | **Code:** EEPS105 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Knowledge of Engineering fundamentals, mathematics, control systems, mechanical and manufacturing process.

**Course Objectives:**

1. To emphasize the role of automation techniques in manufacturing and process industries.
2. To impart the role of PLC in industry automation.
3. To familiarize with the various control techniques used in process automation.
4. To design automation systems for manufacturing and process industries.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Apply automation principles and strategies in manufacturing systems. |
| **CO2** | Design and analyze Detroit-type automated flow lines, transfer mechanisms, and buffer storage for enhanced machining operations. |
| **CO3** | Evaluate and design material handling systems with product identification technologies. |
| **CO4** | Apply control technologies in automation, including industrial control systems, SCADA, and PLCs. |
| **CO5** | Design and analyze automated manufacturing systems, including flexible and cellular manufacturing. |
| **CO6** | Integrate DDC, DCS, SCADA, and PLCs for process safety and control in process industries. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Introduction to automation in Manufacturing Industries:** Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics: Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process. |
| 2. | **Detroit-Type Automation:** Automated Flow lines, Methods of Work part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Computer Simulation of Automated Flow Lines. |

| | |
|---|---|
| 3. | **Material handling and identification technologies:** The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing. Product identification system: Barcode, RFID etc. |
| 4. | **Control technologies in automation:** Industrial Control Systems, Process Industries Verses Discrete Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules, and SCADA System & RTU. |
| 5. | **Automated Manufacturing Systems:** Components, Classification and overview of manufacturing systems, Cellular manufacturing, Flexible manufacturing system (FMS), FMS and its planning and implementation, Automated assembly system – design and types of automated assembly systems, Analysis of multi station and single station assembly machine. |
| 6. | **Automation in Process Industries:** Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation, Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control. |

**Text Books:**

1. M. P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Krishna Kant, "Computer-Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw-Hill, New York.

**Reference Books:**

1. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
2. Lukas M. P., "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.
3. N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", 1st Edition, 2009.
4. Carlos Smith and Corripio, "Principles and Practice of Automatic Process Control", 3rd Edition, John Wiley & Sons, 2006.

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (E&TC – IoT and Sensor Systems) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – I (Internet of Things) | | | | | | | | **Code:** ETIS105 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

1. Basics of sensors and hardware components.
2. Basic networking concepts.
3. Knowledge of Microcontroller and embedded systems.

**Course Objectives:**

To provide students with a comprehensive understanding of sensor and actuator technologies, IoT architecture, communication protocols, and interfacing techniques, alongside their applications in smart environments, industrial systems, and healthcare.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Comprehend and analyze concepts of sensors, actuators, IoT and IoE. |
| **CO2** | Interpret IoT Architecture Design Aspects. |
| **CO3** | Comprehend the operation of IoT protocols. |
| **CO4** | Describe various IoT boards, interfacing, and programming for IoT. |
| **CO5** | Illustrate the technologies, Catalysts, and precursors of IIoT using suitable use cases. |
| **CO6** | Provide suitable solution for domain specific applications of IoT. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1 | **Sensors, Actuators, IoT & IoE:** Definitions, Types of sensors, Types of Actuators, Example and Working, Networking Basics, RFID Principals and components, Wireless Sensor Networks, Definition, and characteristics of an IoT, Physical Design of an IoT, Logical design of IoT, Communication Models, Communication API's, What is the IoE? Difference between IoT and IoE, Pillars of the IoE, Connecting the Unconnected, Transitioning to the IoE, Bringing It All Together. |
| 2 | **IoT Architecture Design Aspects:** IoT-An Architectural Overview, building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service (XaaS), M2M and IoT Analytics, Knowledge Management |
| 3 | **IoT Protocols:** PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, Z Wave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4, IPv6, 6LoWPAN, 6TiSCH, ND, DHCP, ICMP, RPL, CORPL, CARP, Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer HTTP, CoAP, XMPP, AMQP, MQTT. |

| | |
|---|---|
| 4 | **Interfacing Boards and Programming:**<br>Introduction to IoT Boards, Interfacing with IoT Boards, IoT deployment for Raspberry Pi /Arduino/Equivalent platform – Reading from Sensors, Communication: Connecting microcontroller with mobile devices – communication through Bluetooth, wifi and USB - Contiki OS- Cooja Simulator. |
| 5 | **Industrial IoT:**<br>Introduction, Key IIOT technologies, Catalysts, and precursors of IIoT, Innovation and the IIoT, Applications of IIoT Examples: Healthcare, Oil and Gas Industry, Logistics and the Industrial Internet, Retail applications, IoT innovations and design methodologies, Industrial Internet Architecture Framework (IIAF): Control domain, operational domain and application domain, Three tier topology,<br>Design of low power device network, legacy industrial protocols, Bluetooth, Zigbee IP, Z-wave, Wi-Fi backscatter in IIoT design. |
| 6 | **Applications of IoT:**<br>Smart Environment: Forest Fire Detection, Air Pollution, Smart Cities: Parking, Structural Health, Noise Urban maps, Smart Metering: Smart Grid, Tank level, Photovoltaic Installations, Silos Stock Calculation, Health: Fall Detection, Medical Fridges, Sportsmen Care, Patients Surveillance, Ultraviolet Radiation. |

**List of Experiments:**

1. Study of Raspberry-Pi, Beagle board, Arduino, and different operating systems for Raspberry-Pi/Beagle board/Arduino. Understanding the process of OS installation on Raspberry- Pi/Beagle board/Arduino.
2. Open-source prototype platform- Raspberry-Pi/Beagle board/Arduino -Simple program digital read/write using LED and Switch -Analog read/write using sensor and actuators.
3. Interfacing sensors and actuators with Arduino/Raspberry-pi.\
4. IoT based Stepper Motor/DC Motor Control with Arduino/Raspberry Pi.
5. Introduction to MQTT/ CoAP and sending sensor data to cloud using Raspberry-Pi/Beagle board/Arduino.
6. Get the status of a bulb at a remote place (on the LAN) through web.
7. Interfacing Arduino to Bluetooth Module.
8. Communicate between Arduino and Raspberry PI using any wireless medium like ZigBee.

**Text Books:**

1. Ovidiu Vermesan, Peter Fresiss, "Internet of Things" From research and innovation to market Deployment", River Publishers series in Communication, USA.
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2nd Edition, Wiley Publications.

**Reference Books:**

1. Dr. Ovidiu Vermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication.
2. Giancarlo Fortino and Pawan Kumar, "Internet of Things: Case Studies", CRC Press.

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Robotics and Automation Engineering) | | | | | | | **Semester:** I | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – I (Microcontrollers Architecture and Programming) | | | | | | | **Code:** MERA105 | | |
| **Teaching Scheme (hrs./week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Basics of Microcontroller and programming.

**Course Objectives:**

To provide solid foundation on the fundamentals of microprocessors and applications, interfacing the external devices to the processor according to the user requirements thus, enabling to create novel products and solutions for real time problems.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Describe architecture and operation of Microcontroller 8051. |
| **CO2** | Foster ability to understand the design concept of Microcontroller. |
| **CO3** | Design various applications using its peripherals. |
| **CO4** | Analyze the data transfer information through serial and parallel ports. |
| **CO5** | An in-depth knowledge of applying Microcontrollers the concepts on real time applications. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Basics of Microcontroller and Intel 8051 architecture:**<br>Introduction to microcontrollers, difference in controller and processor. Architecture of 8051, Internal block diagram, Internal RAM organization, SFRS, pin functions of 8051, I/O port structure and Operation, External Memory Interface. |
| 2. | **Programming model of 8051:**<br>Instruction classification, Instruction set, Addressing Modes: Immediate, register, direct, indirect and relative, assembler directives (ORG, END), features with examples, I/O Bit and Byte programming using assembly language for LED and seven segment display (SSD) interfacing. Introduction to 8051 programming in C. |
| 3. | **Timer /Counter, Interrupts:**<br>Timer / counter: TMOD, TCON, SCON, SBUF, PCON Registers, Timer modes, programming for time delay using mode 1 and mode 2.<br>**Interrupts:** Introduction to interrupt, Interrupt types and their vector addresses, Interrupt enable register and interrupt priority register (IE, IP) |
| 4 | **Interfacing, Serial Communication and RTOS:**<br>Programming of serial port without interrupt, Serial Communication: Synchronous and asynchronous serial communication, Use of timer to select baud rate for serial communication, interfacing: ADC, DAC, LCD, stepper motor.<br>**RTOS**:<br>Need of RTOS, Architecture of kernel, task scheduler. |

## DEPARTMENT OF MECHANICAL ENGINEERING

**References:**

1. Kenneth J. Ayala, "The 8051 Microcontroller Architecture, Programming & Applications", Penram International.
2. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Tata McGraw-Hill Education, 2008.
3. K. Uma Rao and Andhe Pallavi, "The 8051 Microcontroller – Architecture, Programming and Applications", Pearson Publications.
4. Mazidi and McKinlay, "8051 Microcontroller and Embedded Systems Using Assembly and C", Pearson Publications.

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Numerical Simulation Lab | | | | | | | | **Code:** MEDE106 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| - | 02 | - | 01 | - | - | 25 | - | 25 | 50 |

**Prerequisites:**

System of linear and nonlinear, Partial differentiation, Problem solving and programming.

**Course Objectives:**

1. To understand applications of systems of equations and solve mechanical engineering applications.
2. To apply differential equations to solve the applications in the domain of fluid mechanics, structural etc.
3. To learn numerical integration techniques for engineering applications.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Apply built-in functions in MATLAB/ SCILAB to solve numerical problems |
| **CO2** | Develop code for solving problems on different types of mathematical models and equations (ODE, PDE, Linear and nonlinear equations). |
| **CO3** | Solve simulation problems encountered in mechanical design, vibration analysis, and CAD |
| **CO4** | Model a system and Develop a simulation code for a mini-project |

**List of Experiments:**

1. Heat conduction analysis of 2D plate using ANSYS fluent.
2. Flow and heat transfer analysis of developing flow in a pipe using ANSYS fluent.
3. Solution of Ordinary Equation and System using MATLAB.
4. Simulation of Vibration in Mechanical System using MATLAB.
5. Simulation of spring mass system using MATLAB.
6. Simulation of CAM and Follower mechanism using MATLAB.
7. Introduction to OpenFOAM and fluid flow and heat transfer analysis of a system using OpenFOAM.

**Text Books:**

1. Steven C. Chapra, "Applied Numerical Methods with MATLAB for Engineers and Scientists", Tata McGraw-Hill Publishing Co. Ltd.

**E-Resources:**

1. NPTEL course on Matlab Programming for Numerical Computation by Prof. Niket Kaisare, IIT Madras https://onlinecourses.nptel.ac.in/noc20_ge05/preview
2. NPTEL course on Computational Fluid Dynamics, IIT Kharagpur by Prof. S. Chakraborty, https://nptel.ac.in/courses/112105045

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** I | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Design Engineering Lab-I | | | | | | | | **Code:** MEDE107 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| - | 02 | - | 01 | - | - | 25 | 25 | - | 50 |

**Prerequisites:**

Basic knowledge of Solid Mechanics, Heat Transfer and Finite Element Analysis (FEA)

**Course Objectives:**

1. To solve 1D, 2D & 3D structural problems using ANSYS software.
2. To evaluate steady state & transient thermal concepts.
3. To analyze coupled field analysis problem.
4. To compare software & experimental results obtained in case study

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the basic concepts of computer aided engineering (CAE) and characteristics of various elements required for analysis. |
| **CO2** | Nurture students about the discretization process and criteria for quality mesh. |
| **CO3** | Understand the approaches of finite element method (FEM) and to find displacement and stresses over the body. |
| **CO4** | Develop the knowledge and skills needed to effectively evaluate the results using finite element analysis (FEA). |
| **CO5** | Apply computational technique to solve complex solid mechanics problems and its loading states. |
| **CO6** | Study the applications of CAE in the various domains of the mechanical engineering. |

**List of Experiments:**

**Exp. No. 1 & 4 is compulsory and perform any 1 of remaining:**

1. Distributed load analysis of Chassis frame.
2. Analysis of plane stress & plane strain problem.
3. Perform harmonic and modal analysis of cantilever beam for different cross section.
4. Performance on Buckling analysis of beam by use of Eigen value and nonlinear buckling analysis.

**Reference Books:**

1. Fagan, "Finite Element Analysis – Theory & Practice", Longman Scientific & Technical.
2. J. N. Reddy, "An Introduction to Finite Element Analysis", Tata McGraw Hill Publication Co.
3. Nitin Ghokle, "Practical Finite Element Analysis".

**E-Resources:**

1. Experimental Stress Analysis by Prof. K. Ramesh, IIT Madras
   Experimental Stress Analysis - Course (nptel.ac.in)
2. Thermal Engineering: Basic and Applied, by Prof. Pranab K. Mondal, IIT Guwahati
   Thermal Engineering: Basic and Applied - Course (nptel.ac.in)

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Seminar | | | | | | | | | **Code:** MEDE108 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| - | 02 | - | 01 | - | - | 25 | 25 | - | 50 |

**Prerequisites:**

Students should have the knowledge of basic and advance engineering topics, Industry related advancement and current practices used.

**Course Objectives:**

To explore emerging technologies, enhance research and communication skills, practice presentations and report writing, evaluate engineering problems, discuss societal impacts, and provide constructive feedback.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Analyze current topics in Design Engineering/emerging technologies by performing literature surveys. |
| **CO2** | Conduct literature reviews, evaluate models, draw conclusions, and gain skills in literature surveys and presentations. |
| **CO3** | Write comprehensive reports and aim to publish at least one review paper. |

**Course Contents:**

| **Sr. No.** | **Description** |
|---|---|
| 1 | Under the supervision of a designated guide, each student must study current subjects in the field and related to Design Engineering also connected to the Industry. |
| 2 | Students may select a mechanical system design/Material handling/ /Other Design Technique that takes into account current trends and the significance of the topic to society/Industry. |
| 3 | A thorough literature review, mathematical modeling using a specific technique and an insightful conclusion are anticipated from the seminar research. |
| 4 | The seminar report must be turned in order to comply with the subject's term work requirements. |
| 5 | As a research consequence of the seminar, at least one review paper publication is anticipated. |

**Activities to be conducted in Semester:**

1. Weekly meeting report submission.
2. Review-1 conduction at mid of semester, at internal level - Literature review and methodology of the selected topic, Mathematical model/advancement in technology and findings and its analysis
3. Review-2 conduction at the end of semester, at external level – Comprehensive presentation on the selected topic in external examiner, guide and departmental representatives panel
4. Review-3 comprehensive spiral report checking and submission of at least one review paper.
5. Seminar report writing and submission to department.

**E-Resources:**

1. https://onlinecourses.swayam2.ac.in/ntr20_ed30/preview
2. https://onlinecourses.nptel.ac.in/noc22_hs05

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Design Engineering) | | | | | | | | | **Semester:** I |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Audit Course – I: Technical Paper writing | | | | | | | | | **Code:** MEDE109 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 01 | - | - | - | - | - | - | - | - | - |

**Prerequisites:**

Basic Proficiency in English, Fundamental Research Skills, Introductory Understanding of Academic Writing, Basic Computer Literacy, Interest in Research and Writing, Analytical and Critical Thinking Skills

**Course Objectives:**

1. To Equip Students with Technical Writing Skills.
2. To Instill Ethical Research Practices.
3. To Enhance Grammar and Writing Proficiency.
4. To Foster Research Skills and Knowledge.
5. To Educate on Plagiarism and Authorship.
6. To Develop Citation and Referencing Competence.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | To know the Technical Writing Fundamentals |
| **CO2** | Understanding of Research Ethics and Objectivity |
| **CO3** | Proficiency in Research Writing |
| **CO4** | Development of Research Skills |
| **CO5** | Ability to Avoid Plagiarism |
| **CO6** | Expertise in Citation and Referencing |

**Course Contents:**

| **Sr. No.** | **Description** |
|---|---|
| 1. | Introduction to Ethics in Research, Five Principles of Ethics, Four Codes of Ethics, Discussion of Case Studies |
| 2. | Difference between Technical and Literary Style, Grammar, Common Errors, Sentence Formation, Technical Vocabulary |
| 3. | The different types of Research, Purpose and nature of research, selection and formulation of a research problem, introduction to research writing |
| 4. | Conference abstracts, proposals, projects, research reports, presentations, different styles and different types of manuscripts, different ways of approaching thesis/dissertation writing, Formal Letters and Emails |
| 5. | Plagiarism, Strategies to Avoid Plagiarism, Authorship and copyright in the Digital Age |
| 6. | Citation styles and use, References, Footnotes, Indexing, and Bibliography |

**Reference Books:**

1. Clyde Parker Davis and Detmar Straub, "Writing the Doctoral Dissertation: A Systematic Approach," Gordon Barrons Educational Series, 2008.
2. Gérard Genette and Jane Lewis, "Narrative Discourse: An Essay in Method," Cornell University

Press, 1983.
3. J. Anderson, B.H. Durston, and M. Poole, "Thesis and Assignment Writing," Wiley Eastern Limited, New Delhi, 1970.
4. Sidney Greenbaum, "The Oxford English Grammar," Oxford University Press, Oxford, 1996.
5. Wayne C. Booth and Gregory Colomb, "The Craft of Research," University of Chicago Press, 2008

**E-Resources:**

1. Online course on English for Research Paper Writing, by Dr. Shoba. K. N., National Institute of Technical Teachers Training And Research, Chennai
   https://onlinecourses.swayam2.ac.in/ntr24_ed15/preview
2. Coursera course on Introduction to Technical Writing
   https://www.coursera.org/learn/technical-writing-introduction

## DEPARTMENT OF MECHANICAL ENGINEERING

# SYLLABUS

## SEMESTER - II

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | | **Semester:** II |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Advanced Mechanical Vibrations & Acoustics | | | | | | | | | **Code:** MEDE201 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 04 | - | - | 04 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Engineering Mechanics, Mechanics of Solid, Engineering Mathematics, and Dynamics of Machinery.

**Course Objectives:**

1. To analyze and apply vibration principles to predict responses in various excitation conditions for modeling physical systems.
2. To learn acoustic terms, measurements, and design principles for applying knowledge effectively in acoustic environments.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Formulate and Evaluate MDOF mechanical vibration problems, then utilize the understanding to design the system effectively. |
| **CO2** | Develop mathematical models for transient vibrations and assess their influence on system design for optimal performance and reliability. |
| **CO3** | Utilize vibration measurement instruments for analyzing system vibrations and develop effective strategies for controlling vibration to optimize system performance. |
| **CO4** | Understand the random vibration and analyze the vibration response of single-degree linear systems to predict and optimize system behavior. |
| **CO5** | Analyze self-excited and non-linear vibrations, identifying causes of instability, and effectively apply analysis techniques for optimal system performance. |
| **CO6** | Apply principles of acoustics to ensure compliance with noise regulations. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Multi-Degree Freedom System:**<br>Free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) Flexibility coefficient generalized coordinates, coordinate couplings, Lagrange's equations matrix method Eigenvalues Eigenvector problems, modal analysis, forced vibrations of the un-damped system and modal analysis.<br>Numerical methods - (i) Rayleigh's Method, (ii) Rayleigh-Ritz Method (iii) Holzer's Method (iv) Methods of Matrix iterations |
| 2. | **Transient vibrations:**<br>Response to an impulsive input, Response to step input, Response to a pulse input-rectangular pulse and half sinusoidal pulse |
| 3. | **Vibration Measurement:**<br>FFT analyzer, vibration exciters, signal analysis, time domain and frequency domain analysis of signals, experimental modal analysis, machine conditioning and monitoring, and fault diagnosis. |

| | |
|---|---|
| | **Vibration Control:**<br>Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency, vibration isolation and vibration absorbers, Passive, active, and semi-active control, free layer and constrained layer damping. |
| 4. | **Random Vibrations:**<br>Auto and cross-correlation function, spectral density, response of linear systems, and analysis of narrow-band systems |
| 5. | **Self-Excited and Non-linear Vibrations:**<br>A criterion for stability, cause of instability, and analysis of special cases of self-excited vibrations.: Free vibrations with non-linear elasticity and damping, relaxation oscillations, sub-harmonic response, phase-plane plots, perturbation techniques, Duffing's equation, jump phenomenon, etc. |
| 6. | **Acoustics:**<br>Fundamentals of acoustics, Acoustics of Partitions, Enclosures, Barriers and Mufflers Transmission of Sound: changes in media with normal incidence, changes in media with oblique incidence, sound transmission through a wall, transmission loss for walls - stiffness-controlled region- mass-controlled region - damping-controlled region, Design of Acoustic Enclosures, Barriers, muffler elements. Noise Control Strategies and Applications |

**Text Books:**

1. S. S. Rao, "Mechanical Vibrations", Pearson Education, Delhi.
2. W. T. Thomson, "Theory of Vibrations with Applications", Pearson Education, Delhi.
3. Kewal Pujara, "Vibrations and Noise for Engineers", Dhanpat Rai, Assorted Editorial, New Delhi.
4. Randell Barron, "Industrial Noise Control", Marcel Dekker, CRC Press.
5. M. L. Munjal, "Noise and Vibration Control", World Scientific Publishing Co. Ltd.
6. G. K. Groover, "Mechanical Vibrations", Nem Chand & Bros, Roorkee, India.

**Reference Books:**

1. Leonard Meirovitch, "Fundamentals of Vibration", McGraw Hill International Edition.
2. Ashok Kumar Mallik, "Principles of Vibration Control", Affiliated East-West Press, New Delhi.
3. A. H. Church, "Mechanical Vibrations", John Wiley & Sons Inc.

**E-Resources:**

1. NPTEL course on Introduction to Mechanical Vibration By Prof. Anil Kumar, IIT Roorkee
   https://onlinecourses.nptel.ac.in/noc22_me76/preview
2. NPTEL course on Acoustic and Noise Control by Prof. Abijith Sarkar, IIT Madras
   https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-me32/

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Research Methodology and Intellectual Property Rights | | | | | | | | **Code:** MEDE202 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 04 | - | - | 04 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Basic Understanding of Academic Research, Critical Thinking and Analytical Skills in research, Basic Knowledge of Statistics

**Course Objectives:**

1. To Understanding Research Fundamentals
2. To Define and Framing Research Problems.
3. To Conduct Comprehensive Literature Reviews**:**
4. To Design and Implementing Research

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand research methodology and its technique of defining a research problem. |
| **CO2** | Apply the concept of the literature review in research, developing theoretical and conceptual frameworks and writing a review. |
| **CO3** | Explain the various research designs and their characteristics. |
| **CO4** | Apply the art of interpretation and writing research reports. |
| **CO5** | Analyze the principles and methods of data collection for report writing. |
| **CO6** | Understand the concept of intellectual property rights, the procedure of patent filing, copyright, and Trademark registration. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Research Methodology:** Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India |
| 2. | **Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining Problem, An Illustration |
| 3. | **Reviewing the literature:** Importance of the literature review in research, Bringing clarity and focus to a research problem, Improving research methodology, Broadening the knowledge base in the research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. |

| | |
|---|---|
| 4. | **Research Design:**<br>Meaning of Research Design, Need for Research Design, Features of Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.<br>Design of Sample Surveys: Introduction, Sample Design, Sampling and Nonsampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. |
| 5. | **Data Collection:**<br>Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.<br>**Interpretation and Report Writing**<br>Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout. |
| 6. | **Intellectual Property Rights:**<br>Introduction to IPRs, Basic concepts and need for Intellectual Property – Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO -TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR. |

**Text Books:**

1. Garg, B.L., Karadia, R., Agarwal, F., and Agarwal, U.K., "An Introduction to Research Methodology", RBSA Publishers, 2002.
2. Kothari, C.R., "Research Methodology: Methods and Techniques", Second Edition, New Age International Publishers, New Delhi, 2008.
3. Sinha, S.C. and Dhiman, A.K., "Research Methodology", EssEss Publications, 2nd Volume, 2002.
4. Gupta, S.P., "Statistical Methods", 37th Edition (Revised), Sultan Chand and Sons, New Delhi, 2008.
5. Leon & Leon, "Internet for Everyone", Vikas Publishing House, 2002.

**Reference Books:**

1. Wadehra, B.L., "Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indications", Universal Law Publishing, 2000.
2. Bulakh, Dr. P. M., Patki, Dr. P. S., and Chodhary, Dr. A. S., "Research Methodology", Expert Trading Corporation, Dahisar West, Mumbai, 2010.

**E-Resources:**

1. https://onlinecourses.nptel.ac.in/noc24_ge21
2. https://onlinecourses.nptel.ac.in/noc22_ge08
3. http://nptel.ac.in/courses/121106007
4. Free Course: Research Methodology and IPR from NITTTR | Class Central
5. https://onlinecourses.swayam2.ac.in/cec24_ge02
6. https://onlinecourses.nptel.ac.in/noc21_hs08

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Finite Element Method | | | | | | | | **Code:** MEDE203 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer

**Course Objectives:**

1. To teach the fundamentals of the finite element method with emphasis on the underlying theory assumption and modeling issues.
2. To make students study the 1D, 2D, and 3D analysis for different field problems.
3. To provide hands-on experience using finite element software to model, analyze, and design systems of mechanical engineering.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Apply different variation methods for deriving the stiffness matrices of bar and beam element. |
| **CO2** | Derive and use 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses. |
| **CO3** | Understand the Iso-parametric Elements and Formulation of Plane Elasticity Problems. |
| **CO4** | Create and solve the governing equations for plates using Kirchoff theory and Mindlin plate element theory. |
| **CO5** | Evaluate nonlinear problems related to geometry, material, and contact. |
| **CO6** | Solve real-life mechanical engineering problems. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **One-dimensional problems:**<br>Finite element method, brief history, basic steps, advantages and disadvantages, weak formulation, variational methods of approximation – Rayleigh-Ritz methods, Galerkin method of Weighted Residuals.<br>Variational formulation of 1D bar and beam elements (Euler Bernoulli and Timoshenko beam) – governing equation, domain discretization, elemental equations, assembly and element connectivity, application of boundary condition, solution of equations, post-processing of the results. Automatic mesh generation techniques, Mesh quality checks, h & p refinements, Node Numbering scheme |
| 2. | **Two Two-dimensional isoperimetric Formulation:**<br>Introduction, types of 2D elements (CST, LST, QST, Isoparametric), shape functions – linear & quadratic, displacement function – criteria for the choice of the displacement function, polynomial displacement functions, displacement function in terms of nodal parameters, strain-nodal parameter relationship, stress-strain relationship, element stiffness matrix, |

| | |
|---|---|
| | convergence of Isoparametric elements, rate of convergence, plane elasticity problems – plane stress, plane strain and axisymmetric problems |
| 3. | **Isoparametric Formulation and Numerical Integration:**<br>Isoparametric formulation of 1D and 2D Elements, Subparametric, Superparametric and Isoparameetric Elements, Numerical Integration – Trapezoidal rule, Simpson's 1/3 rule, Newton-Cotes Formula, Gauss Quadrature formula, Gauss Quadrature in two and three dimensions, reduced and selective integration |
| 4. | **Plate Theories:**<br>Thin and thick plates-Kirchhoff theory, Mindlin plate element, triangular and rectangular, conforming and nonconforming elements, degenerated shell elements, shear locking and hour glass phenomenon |
| 5. | **Non-Linear Analysis:**<br>Introduction to non-linear analysis, formulation for geometrical, material and contact nonlinear problems, Nonlinear equation solving procedure - direct iteration, Newton-Raphson method, modified Newton-Raphson method, incremental techniques |
| 6. | **Linear and Non Linear Analysis:**<br>Types of Analysis (Introduction): Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis, Noise, Vibration and Harshness (NVH) analysis<br>Computer implementation of the finite element method: pre-processing, meshing techniques, processing post processing. Static condensation, Sub modeling and subtracting, Patch test and incompatible element, h and p refinements |

**Text Books:**

1. Seshu, P., "Textbook of Finite Element Analysis", PHI Learning Private Ltd., New Delhi, 2010.
2. Chandrupatla, T. R. and Belegundu, A. D., "Introduction to Finite Elements in Engineering", Prentice Hall India.
3. Logan, D., "A First Course in the Finite Element Method", Cengage Learning, 2012.

**Reference Books:**

1. Bathe, K. J., "Finite Element Procedures", Prentice-Hall of India (P) Ltd., New Delhi.
2. Gokhale, N. S., Deshpande, S. S., Bedekar, S. V., and Thite, A. N., "Practical Finite Element Analysis", Finite to Infinite, Pune.
3. Gupta, S. K., "Numerical Methods for Engineers", New Age International, 1995.
4. Cook, R. D., "Finite Element Modeling for Stress Analysis", John Wiley and Sons Inc., 1995.

**E-Resources:**

1. NPTEL course on Finite Element Method by Prof. Biswanath Banerjee, Prof. Amit Shaw, IIT Kharagpur - https://onlinecourses.nptel.ac.in/noc22_me43/preview

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Program Elective – II (Advanced Machine Design) | | | | | | | | **Code:** MEDE204A | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Knowledge of Theory of Machinery, Design of Machine Elements, and Dynamics of Machinery.

**Course Objectives:**

1. To study the fundamental concepts of fatigue and its significance in engineering materials.
2. To study fatigue strength and its implications for material design and durability.
3. To explore the effects of superimposed static stress on fatigue life.
4. To identify surface and Wear Mechanisms.
5. To develop solutions to optimize surface performance and durability in industrial applications.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand Fatigue features. |
| **CO2** | Design mechanical components under creep. |
| **CO3** | Select composite material and design mechanical components. |
| **CO4** | Apply theoretical knowledge about Surface Failure by designing various strategies. |
| **CO5** | Design mechanical components under fracture. |
| **CO6** | Analyze a process of production /member to stand against application hazards and uncertainty using robust design. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Fatigue:** Introduction, Fatigue strength, factors affecting fatigue behavior, Influence of superimposed static stress, Cumulative fatigue damage, fatigue under complex stresses, Fatigue strength after stresses |
| 2. | **Creep:** Introduction, True stress, and true strength, mechanism of creep of material at high temperature, Exponential creep law, hyperbolic sine creep law, stress relaxation, bending, etc. |
| 3. | **Design for Materials and Process:** Introduction, Design for brittle fracture, Design for fatigue failure, Design for different machining processes, assembly & safety, etc. |
| 4. | **Surface Failure:** Introduction, Friction: Rolling, Effect of roughness, velocity, and lubrication on friction, Wear: Adhesive, Abrasive and Corrosive, Lubrication: Hydrodynamic, hydrostatic, and elastohydrodynamic lubrication |
| 5. | **Product / Process Optimization:** Introduction, Signal to Noise Ratios for Static Problems, Signal to Noise Ratios for Dynamic Problems Optimization using Signal to Noise Ratios |

| | |
|---|---|
| | Robust Design: Steps in Robust Design, Fundamental Principle, Tools Used in Robust Design, Application, and Benefits of Robust Design |

**Text Books:**

1. Jack Collins, Henry R. Busby, and George H. Staab, "Mechanical Design of Machine Elements and Machines: A Failure Prevention Perspective", John Wiley & Sons, Inc.
2. Ansel C. Ugural and Saul K. Fenster, "Advanced Mechanics of Materials and Applied Elasticity", Prentice Hall, 5th edition.
3. N. K. Mehta and J. S. Rao, "Advanced Machine Design".
4. L. S. Srinath, "Advanced Mechanics of Solids", McGraw Hill Education, 3rd edition.
5. Richard G. Budynas and Richard J. Schmidt, "Advanced Strength and Applied Stress Analysis", McGraw-Hill.
6. Robert L. Norton, "Machine Design", Pearson.

**Reference Books:**

1. M. F. Spotts, "Mechanical Design Analysis", Prentice-Hall, Inc.
2. Radzevich, S. P. (Ed.), "Dudley's Handbook of Practical Gear Design and Manufacture", 4th ed., CRC Press, 2021.
3. A. M. Wahl, "Mechanical Springs", McGraw-Hill, 1963.
4. Clyne, T. W., & Hull, D., "An Introduction to Composite Materials", 3rd ed., Cambridge University Press, 2019.
5. Efrén M. Benavides and David H. Myszka, "Advanced Engineering Design: An Integrated Approach", Woodhead Publishing, Cambridge, UK, Philadelphia, PA.
6. Nam-Ho Kim, Bhavani V. Sankar, and Ashok V. Kumar, "Advanced Finite Element Analysis and Optimization: With MATLAB and ANSYS", John Wiley & Sons, 2018.
7. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley.
8. Robert L. Norton, "Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines", McGraw-Hill.

**E-Resources:**

1. NPTEL Course on Fracture, Fatigue, and Failure of Materials by Prof. Indrani Sen, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc22_mm42/preview
2. NPTEL Course on Mechanical Behavior of Materials by Prof. Sankaran.S. IIT Madras By Prof. Sankaran.S, IIT Madras https://onlinecourses.nptel.ac.in/noc23_mm38/preview
3. NPTEL Course on Basics of Materials Engineering by Prof. Ratna Kumar Annabattula, IIT Madras https://onlinecourses.nptel.ac.in/noc23_me78/preview

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Program Elective – II (Fatigue and Fracture Analysis) | | | | | | | | **Code:** MEDE204B | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Introductory courses on (a) Materials Science and Engineering, (b) Mechanical behavior of materials

**Course Objectives:**

1. To Understand Fatigue Mechanics including the microscopic theories of fracture.
2. To design and execute fatigue testing experiments using appropriate apparatus.
3. To explore the impact of various factors such as temperature, frequency, and environmental conditions on fatigue behavior.
4. To apply principles of linear elastic and elastic-plastic fracture mechanics to analyze crack initiation and propagation

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the basics of fatigue and fracture mechanisms. |
| **CO2** | Apply experimental techniques to determine fatigue life. |
| **CO3** | Analyze fatigue failures in real-life applications. |
| **CO4** | Apply linear elastic fracture mechanics to predict brittle fracture. |
| **CO5** | Apply the stress intensity factor and Fracture toughness testing for failure analysis. |
| **CO6** | Understand Crack growth resistance curves and apply von Mises and Tresca yielding criteria for crack analysis. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Fatigue Mechanics:** Introduction to Fatigue, Stress Controlled Fatigue, Microscopic theories of fracture: Ductile and cleavage fracture, ductile-brittle transition, inter-granular fracture; Fatigue crack propagation: Fatigue crack growth theories, crack closure, Microscopic theories of fatigue crack growth; Application of theories of fracture mechanics in design and materials development |
| 2. | **Fatigue Testing:** Fatigue Test- fatigue testing apparatus, S-N Curve for ferrous and non-ferrous, fatigue fracture, methods of improving fatigue life, creep Test: creep curve, creep fracture, Data acquisition and instrumentation, classical methods of fatigue testing, ASTM standards - specimen preparation, procedure, Safe life and fail-safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to composite materials and structures. |
| 3. | **Special Cases in Fatigue:** Fatigue in Materials, Effect of Temperature on Fatigue, Fatigue analysis in the frequency domain, vibration fatigue, fatigue of welded structure, corrosion fatigue, high-temperature and low-temperature fatigue, fatigue analysis of wind turbines |

| | |
|---|---|
| 4. | **Linear Elastic Fracture Mechanics:**<br>Mechanisms of fracture, initiation of fracture and crack propagation, stress and energy criteria and fracture - effects of geometry, Inglis theory of stress, energy concept – Griffith theory of fracture, Griffith Criteria-Modification, The stress analysis of crack tips, Macroscopic theories in crack extension, Instability and R-curves, Crack tip plasticity, K as a failure criterion, Mixed mode of fracture, Analytical and Experimental methods of determining K. |
| 5. | **Stress Intensity factors and Fracture toughness:**<br>Concept of Stress Intensity Factor, Fracture Toughness and Plane Stress-Plane Strain, Plastic Zone Size , Plane stress and plane strain fracture toughness, Plane Stress Fracture Toughness, Plane Strain Fracture Toughness Testing, calculation for center crack, single edge crack, double edge crack, round hole with crack, superposition of stress intensity factors, leak before break (LBB) criterion |
| 6. | **Elastic-Plastic Fracture Mechanics:**<br>Crack tip opening displacement, J Integrals, Experimental determination of JIC, Crack growth resistance curves, Crack tip constraint under large scale yielding, creep crack growth; crack tip stress state, Irwin's stress intensity factors, Dugdale's approximation, crack opening displacement, shape of the plastic zone – von Mises and Tresca yielding criteria. |

**Text Books:**

1. T. L. Anderson, "Fracture Mechanics: Fundamentals and Applications", CRC Press, 1994.
2. D. Brock, "Elementary Engineering Fracture Mechanics", Martinus Nijhoff Publishers, 1982.
3. S. T. Rolfe and J. M. Barson, "Fracture and Fatigue Control in Structures", PHI, 1977.
4. Yung-Li Lee, "Fatigue Testing and Analysis: Theory and Practice", Elsevier.
5. Japp Schijve, "Fatigue of Structures and Materials", Kluwer Academic.
6. Ali Fatemi, "Metal Fatigue in Engineering", Wiley-Interscience.
7. Prashant Kumar, "Elements of Fracture Mechanics", McGraw Hill Education.

**Reference Books:**

1. Dieter Radaj, "Design & Analysis of Fatigue Resistant Welded Structures", Woodhead Publishing.
2. Nestor Perez, "Fracture Mechanics", Kluwer Academic Publishers.
3. Gdoutos, E. E., "Fracture Mechanics: An Introduction", Springer.
4. Ashok Saxena, "Nonlinear Fracture Mechanics for Engineers", CRC Press.
5. Hertzberg, R. W., "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, Inc.

**E-Resources:**

1. NPTEL course on Fracture, Fatigue and Failure of Materials By Prof. Indrani Sen, IIT Kharagpur, https://archive.nptel.ac.in/courses/113/105/113105106/

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Computer – Data Science) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – II (IoT and Sensor Data Analysis) | | | | | | | | **Code:** CODS205 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

1. Basic understanding of computer networks and data communications.
2. Fundamental knowledge of data structures and algorithms.
3. Programming skills in Python or similar languages.
4. Basic knowledge of statistics and data analysis techniques.

**Course Objectives:**

1. To understand the fundamentals of IoT and sensor technologies.
2. To analyze and process sensor data using various techniques.
3. To develop and implement algorithms for real-time data analysis.
4. To explore applications of IoT data in various domains.
5. To design and evaluate sensor-based systems and applications.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the architecture and components of IoT systems. |
| **CO2** | Acquire and pre-process sensor data effectively to implement techniques for data cleaning and normalization. |
| **CO3** | Apply statistical and machine learning techniques to sensor data. |
| **CO4** | Integrate data from multiple sensors to enhance analysis. |
| **CO5** | Analyze the impact of security practices on sensor data analysis. |
| **CO6** | Explore real-world applications of IoT and sensor data analysis. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Overview of IoT:**<br>Definition, Evolution, and Architecture, Sensor Technologies: Types, Characteristics, and Applications, IoT Communication Protocols: MQTT, CoAP, HTTP, etc.<br>IoT Device Management and Integration. |
| 2. | **Sensor Data Acquisition:**<br>Sampling, Data Formats, and Storage, Data Preprocessing Techniques: Cleaning, Normalization, and Transformation, Handling Missing and Noisy Data.<br>Data Storage Solutions for IoT: Cloud and Edge Storage. |
| 3. | **Statistical Analysis of Sensor Data:**<br>Descriptive and Inferential Statistics, Machine Learning Techniques: Classification, Regression, and Clustering, Time-Series Analysis and Forecasting, Real-Time Data Processing and Analysis. |
| 4. | **Advanced Analytics Techniques:**<br>Deep Learning, Anomaly Detection, Data Fusion Methods: Sensor Fusion, Multi-Modal Data |

| | |
|---|---|
| | Integration, Case Studies: Smart Cities, Industrial IoT, Tools and Frameworks for Advanced Analytics. |
| 5. | **Security Challenges in IoT:** Threats and Vulnerabilities, Cryptographic Techniques and Protocols for IoT Security, Privacy Concerns and Data Protection Regulations, Security Best Practices for Sensor Data Management. |
| 6. | **Applications in Various Domains:** Healthcare, Agriculture, Smart Homes, etc., Case Studies: Real-World Implementations and Solutions, Project Development: Designing, Implementing, and Evaluating IoT Solutions, Future Trends and Innovations in IoT and Sensor Data Analysis. |

**Text Books:**

1. Buyya Rajkumar, Satish Narayana Srirama, "Internet of Things: Principles and Paradigms," Morgan Kaufmann.
2. Hoang D. M. T., S. B. S. Lee, "Data Science for IoT Engineers," Wiley.

**Reference Books:**

1. De Silva Clarence W., "Sensors and Actuators: Engineering System Instrumentation," CRC Press.
2. Liu H., and M. R. Lyu, "Data Mining for the Internet of Things: Techniques and Applications," Springer.
3. Bahga Arshdeep and Vijay Madisetti, "Internet of Things: A Hands-On Approach," VPT.

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Electrical – Power Systems) | | | | | | | | | **Semester:** II |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – II (Electrical Vehicles) | | | | | | | | | **Code:** EEPS205 |
| **Teaching Scheme** | | | | **Evaluation Scheme** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Power Electronics, Control Systems.

**Course Objectives:**

1. To distinguish between different configuration of electric vehicles with merits and demerits.
2. To recommend drive for EV applications with suitable energy storage technology.

**Course Outcomes:** At the end of course, student will be able to -

| | |
|---|---|
| **CO1** | Explore the history, development, and configurations of EVs and hybrid EVs, focusing on efficiency and energy storage. |
| **CO2** | Analyze EV battery specifications, charging cycles, drives, and converter topologies. |
| **CO3** | Examine energy sources, battery features, charging methods (conductive and inductive), and charging infrastructures, including domestic, public, and fast-charging stations. |
| **CO4** | Select appropriate motor and converter for EV applications. |
| **CO5** | Study EV power devices, power electronics converters along with its switching methods for EV operation. |
| **CO6** | Investigate particular drive for EV including speed control methods and advanced control strategies like FOC and adaptive control. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1 | **Introduction to EV:** History and development of on-road Electric Vehicles (EV). Different configurations of hybrid EVs with block diagram representation, merits & demerits of different configurations in view of vehicle efficiency and energy storage system. |
| 2 | **Basics of EV batteries:** Specifications of batteries, power density, Energy density, Charging & Discharging cycle and recommended methodologies for charging. Recommended drives for EV and converter topology used in EVs. |
| 3 | **Energy Sources & Charging:** Different Batteries and Ultra-capacitors, Battery characteristics (Discharging &Charging) Battery Chargers: Conductive (Basic charger circuits, microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication Methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move and-charge zone. |

| | |
|---|---|
| 4 | **EV Propulsion- Electric Motor:**<br>Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors, Comparison of Electric Motors for EV applications. |
| 5 | **Power Electronics & Control requirement for EV:**<br>Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies. |
| 6 | **EV Motor Drives:**<br>DC Motor: Type of wound-field DC Motor, Torque speed characteristics DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control. |

**Text Books:**

1. Dr. S. Sujatha, Senthil Kumar, 'A textbook on Electric vehicle technology'Scientific International Publishing House.
2. Stefano Longo Mehrdad Ehsani, Yimin Gao, 'Modern electric, Hybrid electric & fuel cell vehicles, Taylor & Fransis Exclusive

**Reference Books:**

1. Amelie Ewert, Stephan Schmid, et al., 'Small Electric vehicles : An international view on light three and four wheeler, Springer publications
2. Ron Hodkinson & John Fenton, Light Weight Electric/Hybrid Vehicle design, Butterworth Publications, Heinemann.
3. Marcedle Kkeirn, H.A.Kiehne, 'Battery Technology Handbook', Sandeep Dhameja, Electric vehicle battery systems, Butterworth–Heinemann

**E-Resources:**

1. NPTEL :: Electrical Engineering - NOC: Electric vehicles and Renewable energy

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (E&TC – IoT and Sensor Systems) | | | | | | | | | **Semester:** II |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – II (Embedded System) | | | | | | | | | **Code:** ETIS205 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Microcontrollers

**Course Objectives:**

Introduce students to the principles and programming of real-time operating systems, emphasizing task management, scheduling, and data protection in embedded applications.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Describe the fundamental concepts, characteristics, and components of embedded systems, including the design issues, flow, and metrics. |
| **CO2** | Demonstrate proficiency in the embedded software development process and tools, including linking, locating, and integrating software into target systems. |
| **CO3** | Analyze the ARM architecture, including its design philosophy, register banking, pipelining, and interrupt handling mechanisms. |
| **CO4** | Utilize Embedded C programming to interface with peripherals on the LPC 2148 microcontroller, including LEDs, LCDs, keyboards, and ADCs. |
| **CO5** | Develop practical applications and projects using Embedded C and the LPC 2148 microcontroller, demonstrating hands-on proficiency. |
| **CO6** | Apply the concepts of real-time operating systems, including task scheduling, shared data management, and the use of semaphores to protect shared data, in embedded applications. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Introduction to Embedded Systems:** Embedded System Definition and Characteristics: Definition, characteristics, and components of an embedded system. Design Issues and Flow: Embedded system design issues, design flow, and metrics. Hardware-Software Design: Issues in hardware-software design and co-design. Introduction to IDE. |
| 2. | **Embedded Software Development:** Development Process and Tools: Introduction to the embedded software development process and tools.Linking and Locating Software: Techniques for linking and locating software, getting embedded software into the target system. |
| 3. | **ARM Architecture and Embedded Processor:** ARM Architecture Details: RISC architecture design philosophy, register banking, CPSR, and SPSR. Pipelining and Interrupts: Pipelining, exceptions, interrupts, and the vector table in ARM architecture. |

| | |
|---|---|
| 4. | **LPC 2148 Microcontroller:**<br>Microcontroller Architecture: ARM7TDMI-S microcontroller LPC-2148 architecture details, SFRs, and port structure. Peripheral Modules: Timer, counter, PWM module, and Embedded C programming for interfacing LEDs and LCDs. |
| 5. | **Embedded C Programming:**<br>Advanced Interfacing: Embedded C programming for interfacing with keyboards and ADC.Practical Applications: Hands-on projects and real-world applications using LPC 2148. |
| 6. | **Real Time Operating System (RTOS):**<br>RTOS Concepts and Architectures: Introduction to RTOS concepts and embedded software architectures: round robin, round robin with interrupts, function queue scheduling, and real-time operating systems.RTOS Programming and Task Management: Tasks and task states, task scheduling, shared data and reentrancy, semaphores, and protecting shared data using semaphores. |
| **Text Books:** | |
| 1. James K. Peckol. "Embedded Systems: A Contemporary Design Tool", John Wiley & Sons.<br>2. Raj Kamal. "Embedded Systems: Architecture, Programming and Design", McGraw-Hill Education. | |
| **Reference Books:** | |
| 1. Joseph Yiu. "The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors", Newnes.<br>2. Michael Barr and Anthony Massa. "Programming Embedded Systems: With C and GNU Development Tools", O'Reilly Media.<br>3. Real-Time Systems: Design Principles for Distributed Embedded Applications, Springer. | |

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Robotics and Automation Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Open Elective – II (Micro Electro Mechanical Systems) | | | | | | | | **Code:** MERA205 | |
| **Teaching Scheme (hrs./week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 03 | - | - | 03 | 50 | 50 | - | - | - | 100 |

**Prerequisites:**

Fundamental of electrical and electronics engineering; Mechatronics; Manufacturing machine tools.

**Course Objectives:**

To explore micro engineering devices, electrostatic sensor principles, piezoelectric materials and transducers, micromachining terms, and polymers in MEMS.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Understand the operation of micro devices, micro systems and their applications. |
| **CO2** | Apply scaling laws that are used extensively in the conceptual design of micro devices and systems. |
| **CO3** | Choose a micromachining technique, such as bulk micromachining and surface micromachining for a specific MEMS fabrication process. |
| **CO4** | Simplify the design of micro devices, micro systems using the MEMS fabrication process. |
| **CO5** | Select suitable polymer for given application. |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **Introduction:** Intrinsic Characteristics of MEMS, Energy Domains and Transducers, Sensors and Actuators, Introduction to Microfabrication, Silicon-Based MEMS Processes, New Materials, Review of Electrical and Mechanical Concepts in MEMS, Semiconductor Devices, Stress and Strain Analysis, Flexural Beam Bending, Torsional Deflection. |
| 2. | **Electrostatic Sensing and Actuation:** Introduction to Electrostatic Sensors and Actuators, Parallel-Plate Capacitors, Applications of Parallel Plate Capacitors, Interdigitated Finger Capacitors, Applications of Comb Drive Devices. Thermal Sensing and Actuation: Introduction, Sensors and Actuators Based on Thermal Expansion, Thermal Couples, Thermal Resistors, Applications. Magnetic Actuation: Essential Concepts and Principles, Fabrication of Micro Magnetic Components, Case Studies of MEMS Magnetic Actuators. Piezo Resistive Sensors: Piezo resistive Sensor Materials, Stress Analysis of Mechanical Elements, Applications of Piezo Resistive Sensors. Piezoelectric Sensing and Actuation: Introduction, Properties of Piezoelectric Materials, Applications. |
| 3. | **Sensors and Actuators:** Piezo-Resistive Sensors, Piezo-Resistive Sensor Materials, Stress Analysis of Mechanical Elements, Applications to Inertia, Pressure, Tactile, and Flow Sensors, Piezoelectric Sensors and Actuators, Piezoelectric Effects, Piezoelectric Materials, Applications to Inertia, Acoustic, Tactile, and Flow Sensors. |

| | |
|---|---|
| 4. | **Micromachining:**<br>Silicon Anisotropic Etching, Anisotropic Wet Etching, Dry Etching of Silicon, Plasma Etching, Deep Reactive Ion Etching (DRIE), Isotropic Wet Etching, Gas Phase Etchants, Case Studies, Basic Surface Micro-Machining Processes, Structural and Sacrificial Materials, Acceleration of Sacrificial Etch, Stiction and Anti-Stiction Methods, LIGA Process, Assembly of 3D MEMS. |
| 5. | **Polymer and Optical MEMS:**<br>Polyimide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene, Fluorocarbon, Application to Acceleration, Pressure, Flow, and Tactile Sensors, Optical MEMS, Lenses and Mirrors, Actuators for Active Optical MEMS |

**Text Books:**

1. Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2012.
2. Stephen D. Senturia, "Microsystem Design", Springer Publication, 2000.
3. Dr. T. Kamatchi, "Fundamentals of Micro-electromechanical Systems (MEMS)", Technical Publication.
4. Nadim Maluf, Kirt Williams, "An Introduction to Micro-electromechanical Systems Engineering", Artech House, Boston.

**Reference Books:**

1. Tai Ran Hsu, "MEMS & Microsystems Design and Manufacture", TMH, New Delhi, 2002.
2. Marc Madou, "Fundamentals of Microfabrication".

**E-Resources:**

1. https://nptel.ac.in/courses/108106165
2. https://www.me.iitb.ac.in/~gandhi/me645/05L1_coursecontents_mtvn.pdf
3. https://www.edx.org/learn/engineering/ecole-polytechnique-federale-de-lausanne-micro-and-nanofabrication-mems
4. https://engineering.purdue.edu/online/courses/fundamentals-mems

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | **Semester:** II | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Program Elective Lab - I | | | | | | | **Code:** MEDE206 | | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| - | 02 | - | 01 | - | - | 25 | 25 | - | 50 |

**Prerequisites:**

1. Elective-I:-Basic knowledge of Engineering Mechanics, Materials Science, Mechanical Design Fundamentals and Failure Mode Effects Analysis (FMEA).
2. Elective-II: - Basic knowledge of Engineering Solid Mechanics, Mechanical Properties of Materials and Experimental Techniques Finite Element Analysis (FEA).

**Course Objectives:**

**Elective 1: Advanced Machine Design**

1. To analyze Failure Modes
2. To evaluate Surface Integrity
3. To optimize Design Processes

**Elective 2- Fatigue and Fracture Analysis**

1. To apply Fatigue Analysis Techniques
2. To conduct Stress/Strain Analysis
3. To implement Experimental Techniques

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Solve open-ended Design problem and report the solution. |
| **CO2** | Simulate the problem and correlate it with theoretical concepts. |
| **CO3** | Understand the impact of assumptions on the simulated results. |
| **CO4** | Collect data, analyze, interpret, and report the results. |

**List of Experiments:**

**Elective 1- Advanced Machine Design**

1. Case Studies based on: Failure Mode Effect Analysis.
2. Case Studies based on: Surface Failure.
3. Case Studies based on: Process Optimization.
4. Case Studies based on: Design based on Quality and Reliability.
5. Case Studies based on: Design based on Cost.

**Elective 2- Fatigue and Fracture Analysis**

1. Case Studies based on: Rain Flow Counting Technique.
2. Stress / Strain Based Fatigue Analysis.
3. FEA Simulation of Fatigue / Fracture Problem.
4. Crack tip stresses using Photo elasticity.
5. Stress Analysis Using Image Processing.

**E-Resources:**

**Elective 1- Advanced Machine Design:**

1. NPTEL course on Failure analysis and Prevention by Prof. D K Dwivedi, IIT Roorkee

https://onlinecourses.nptel.ac.in/noc20_me26/preview

2. NPTEL course on Fracture, Fatigue and Failure of Materials by Prof. Indrani Sen, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc22_mm42/preview
3. NPTEL course on Reliability-Based Structural Design by Prof. Arunasis Chakarborty, IIT Guwahati https://onlinecourses.nptel.ac.in/noc24_ce91/preview

**Elective 2- Fatigue and Fracture Analysis:**

1. NPTEL course on Engineering Fracture Mechanics by Prof. K. Ramesh, IIT Madras - https://onlinecourses.nptel.ac.in/noc24_me113/preview
2. NPTEL course on Experimental Stress Analysis by Prof. K. Ramesh, IIT Madras https://onlinecourses.nptel.ac.in/noc22_me67/preview

## DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Design Engineering Lab – II | | | | | | | | **Code:** MEDE207 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| - | 02 | - | 01 | - | - | 25 | 25 | - | 50 |

**Prerequisites:**

1. Basic knowledge of Solid Mechanics.
2. Basic knowledge of Kinematics.

**Course Objectives:**

1. To apply design engineering principles and methodologies to develop innovative solutions.
2. To conduct experiments and tests to evaluate the performance of designed systems/components.
3. To use computational tools and software for design analysis and optimization.

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Analyze and interpret the results to determine the relationship between strain and stress. |
| **CO2** | Apply the principles of polariscope to analyze and solve problems in engineering and scientific applications, such as stress analysis, material characterization, and optical filtering. |
| **CO3** | Apply the principles of statics and mechanics of materials to analyze the stress and deflection of beams under various loading conditions. |
| **CO4** | Analyze and explain the motion of the Klann mechanism, including the displacement, velocity, and acceleration of its links. |
| **CO5** | Analyze and interpret the position curves and workspace of a 4-bar RRRR Grashofian Crank Rocker Mechanism using graphical and analytical methods. |
| **CO6** | Understand the fundamental concepts of digital image processing, including image representation, storage, and manipulation. |

**List of Experiments:**

**Perform any five experiments:**

1. Strain gauge Wheatstone bridge circuit.
2. To measure the strain in a loaded steel cantilever using strain gauges.
3. Study of Polaris cope and its components.
4. Stress Analysis of Pure Beam Bending.
5. Perform the experiment on the klann mechanism and understand the simple one-degree freedom walking mechanism and find out the applications of coupled four-bar mechanisms.
6. Complete the experiment on Chebyshev's straight line mechanism and find out the position of the links using angles, thereby understanding the application of four-bar mechanisms in the walking mechanism.
7. To Study the Position Analysis of a 4 Bar RRRR Grashofian Crank Rocker Mechanism Position Analysis of a 4 Bar RRRR Grashofian Crank Rocker Mechanism.
8. Digital image processing techniques (DIP).

## DEPARTMENT OF MECHANICAL ENGINEERING

**Reference Books:**

1. Richard L. Hannah and Samuel E. Reed, "Strain Gage Users' Handbook", Chapman and Hall, New edition.
2. Ansel C. Ugural and Saul K. Fenster, "Advanced Mechanics of Materials and Applied Elasticity", Prentice Hall; 5th edition.
3. N. K. Mehta, "Machine Tools Design", Tata McGraw-Hill.
4. Pericles S. Theocaris and Emmanuel E. Gdoutos, "Matrix Theory of Photoelasticity", Springer Series in Optical Sciences (SSOS, volume 11).
5. Richard G. Budynas, "Advanced Strength and Applied Stress Analysis", McGraw-Hill Education; 2nd edition.
6. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Education; Fourth edition.

**E-Resources:**

1. NPTEL course on Experimental Stress Analysis by Prof. K. Ramesh, IIT Madras
   https://archive.nptel.ac.in/courses/112/106/112106068/
2. NPTEL course on Mechanics of Solids by Prof. Priyanka Ghosh, IIT Kanpur
   https://archive.nptel.ac.in/courses/105/104/105104160/#

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical–Design Engineering) | | | | | | | | **Semester:** II | |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Dissertation Phase – I | | | | | | | | **Code:** MEDE208 | |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| | 02 | - | 01 | - | - | 25 | 25 | - | 50 |

**Prerequisites:**

Basic knowledge of Machine Design, Mechanical system design, Basics of Analysis software.

**Course Objectives:**

1. To conduct review of literature to arrive at selected advanced topic for the research work.
2. To enable students to apply their knowledge about research design and methods to develop their project.
3. To inculcate research culture in students for their technical growth.

**Course outcome:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Identify a topic in advanced areas of design engineering |
| **CO2** | Review literature to identify gaps and define the objectives and scope of the work |
| **CO3** | Employ the ideas from the literature and develop a research methodology |
| **CO4** | Prepare good-quality technical reports based on the project |
| **CO5** | Prepare a good-quality research paper |

**Course Contents:**

| **Sr. No.** | **Description** |
|---|---|
| 1. | Selection of Topic |
| 2. | Literature Survey |
| 3. | Defining the Objectives and Solution Methodology |
| 4. | Performance of the Task |
| 5. | ➢ Under the guidance of a faculty called as Supervisor, PG students from first year is required to do innovative and research-oriented work related to various theory and laboratory courses he/she studied during previous semesters. Dissertation work should not be limited to analytical formulation, experimentation or survey based project.<br>➢ Student need to carry out an exhaustive literature survey with consultation of his/her Supervisor for not less than 25 reputed national international journals and conference papers. Students should make the Presentation with literature survey report to justify about the innovativeness, applicability relevance and significance of the work.<br>➢ At the time of presentation, student shall also prepare Synopsis of the work and submit to department for approval.<br>➢ Student shall submit dissertation as per the prescribed format to department. |

# DEPARTMENT OF MECHANICAL ENGINEERING

| **Program:** M. Tech. (Mechanical - Design Engineering) | | | | | | | | | **Semester:** II |
|---|---|---|---|---|---|---|---|---|---|
| **Course:** Audit Course – II : Constitution of India | | | | | | | | | **Code:** MEDE209 |
| **Teaching Scheme (hrs/week)** | | | | **Evaluation Scheme (Marks)** | | | | | |
| **Lecture** | **Practical** | **Tutorial** | **Credit** | **CIE** | **ETE** | **TW** | **OR** | **PR** | **Total** |
| 01 | - | - | - | - | - | - | - | - | - |

**Prerequisites:**

1. Understanding of Indian History and Political Science
2. Familiarity with Constitutional Law and Governance
3. Awareness of Socio-economic and Cultural Diversity in India
4. Knowledge of Democratic Processes and Institutions

**Course Objectives:**

1. Examine the Historical Development of the Indian Constitution
2. Critically Analyze the Philosophical Foundations of the Indian Constitution
3. Explore the Scope and Implications of Constitutional Rights and Duties
4. Understand the Structure and Functions of Key Organs of Governance
5. Analyze the Mechanisms and Practices of Local Administration
6. Evaluate the Role and Functioning of Electoral Institutions

**Course Outcomes:** At the end of the course, the student will be able to -

| | |
|---|---|
| **CO1** | Demonstrate an understanding of the Historical Context and Evolution of the Indian Constitution |
| **CO2** | Evaluate the Philosophical Foundations of the Indian Constitution |
| **CO3** | Explain the Scope and Significance of Constitutional Rights and Duties |
| **CO4** | Describe the Structure and Functions of Key Organs of Governance |
| **CO5** | Evaluate the Functioning of Local Administration and Grassroot Democracy |
| **CO6** | Analyze the Role and Functioning of Electoral Institutions |

**Course Contents:**

| **Unit** | **Description** |
|---|---|
| 1. | **History of Making of the Indian Constitution:**<br>History, Drafting Committee (Composition & Working) |
| 2. | **Philosophy of the Indian Constitution:**<br>Preamble, Salient Features |
| 3. | **Contours of Constitutional Rights & Duties:**<br>Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties. |
| 4. | **Organs of Governance:**<br>Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions. |

| | |
|---|---|
| 5. | **Local Administration:**<br>District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation, Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role, Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy |
| 6. | **Election Commission:**<br>Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women |

**Reference Books:**

1. "The Constitution of India, 1950 (Bare Act)", Government Publication.
2. Dr. S. N. Busi, "Dr. B. R. Ambedkar Framing of Indian Constitution", 1st Edition, 2015.
3. M. P. Jain, "Indian Constitution Law", 7th Edn., Lexis Nexis, 2014.
4. D. D. Basu, "Introduction to the Constitution of India", Lexis Nexis.

**E-Resources:**

1. Constitution of India - National Portal of India https://www.constitutionofindia.net/read/ https://legislative.gov.in/constitution-of-india/
2. PRS Legislative Research - Articles on Indian Constitution https://prsindia.org/
3. Election Commission of India - Official Website