**Rashtreeya Sikshana Samithi Trust**

# R.V. College of Engineering

*(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

## Department of Mechanical Engineering

**Master of Technology (M. Tech.)**

# Machine Design

## Scheme and Syllabus of Autonomous System w.e.f 2016

# R.V. College of Engineering, Bengaluru – 59

*(Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

## Department of Mechanical Engineering

**Vision:**

Quality education in Design, Materials, Thermal and Manufacturing with emphasis on research, sustainable technologies and entrepreneurship for societal symbiosis.

**Mission:**

- Imparting knowledge in basic and applied areas of Mechanical Engineering.
- Providing state-of-the-art laboratories and infrastructure for academics and research in the areas of design, materials, thermal engineering and manufacturing.
- Facilitating faculty development through continuous improvement programs.
- Promoting research, education and training in materials, design, manufacturing, Thermal Engineering and other multidisciplinary areas.
- Strengthening collaboration with industries, research organizations and institutes for internship, joint research and consultancy.
- Imbibing social and ethical values in students, staff and faculty through personality development programs

**Program Educational Objectives (PEO)**

The Graduates of M. Tech. in Machine Design Program will be prepared for:

**PEO1** Practicing design of engineering systems through the application of the fundamental knowledge and skills of Mechanical Engineering.

**PEO2** Enhancing their skills through training, independent inquiry, and professional development.

**PEO3** Working independently as well as collaboratively, while demonstrating the professional and ethical responsibilities of the engineering profession.

## Program Outcomes (PO)

M. Tech. in Machine Design graduates will be able to:

**PO1:** Apply the knowledge of Mathematics and Engineering for machine design

**PO2:** Identify and analyze the engineering challenges / problems regarding human needs in daily life about machines and systems.

**PO3:** Design and develop engineering solutions for global progress, productivity and economic development.

**PO4:** Use of modern tools and techniques for modeling and analysis of complex engineering systems.

**PO5:** Understand the impact of Machine Design engineering on all aspects of environment and society and to demonstrate the knowledge and need for sustainable development.

**PO6:** Work as professionals in accordance with the norms of Machine Design engineering practices and commit to societal, ethical and professional responsibilities.

**PO7:** Apply professional, ethical, legal, security and social issues in the design systems.

**PO8:** Demonstrate design principles to work as team member and / or leader in multidisciplinary areas of engineering

**PO9:** Communicate effectively through written and oral modes.

**PO10:** Understand and apply project management techniques, tools and practices to plan manage and complete an Engineering Design project.

**PO11:** Engage in independent and lifelong learning by pursuing higher studies and training.

## Program Specific Criteria (PSC) as per American Society of Mechanical Engineers

The curriculum is designed to enable the students to (a) apply principles of engineering design, analysis, selection of materials and manufacturing processes using modern tools and techniques to new products; (b) be proficient in costing, quality assessment and its life cycle management; (c) work in teams, communicate effectively, demonstrate concern for environment and sustainability of products and processes.

The faculty members of the program possess in-depth understanding and expertise in their areas of specialization with a commitment to periodically update their knowledge in respective domains.

## Program Specific Outcomes (PSO)

M. Tech. in Machine Design graduates will be able to:

**PSO 1**: Design Mechanical systems using interrelationship among force, stress, vibration and failure analysis.

**PSO 2**: Develop advanced analysis tools for evaluating performance of mechanical systems to enhance the capability of the designer.

**R. V. College of Engineering, Bengaluru – 59.**

*(An Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**Department of Mechanical Engineering**

## M. Tech. in Machine Design

| FIRST SEMESTER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | | | | **Total Credits** |
| | | | | **Lecture L** | **Tutorial T** | **Practical P** | **Self-Study S** | |
| 1 | 16MEM11P | Project Management | IM | 3 | 1 | 0 | 0 | 4 |
| 2 | 16MAT12C | Advanced Mathematics | MA | 4 | 0 | 0 | 0 | 4 |
| 3 | 16MMD13 | Advanced Finite Element Methods (Theory & Practice) | ME | 4 | 0 | 1 | 0 | 5 |
| 4 | 16MMD14 | Advanced Theory of Vibrations | ME | 4 | 0 | 0 | 1 | 5 |
| 5 | 16MMD15X | Elective 1 | ME | 4 | 0 | 0 | 0 | 4 |
| 6 | 16HSS16 | Professional Skill Development | HSS | 0 | 0 | 2 | 0 | 2 |
| | | **Total** | | **19** | **1** | **3** | **1** | **24** |

| Elective 1 | | | |
|---|---|---|---|
| 16MMD151 | Advanced Solid Mechanics | 16MMD152 | Acoustics and Noise Control |

**R. V. College of Engineering, Bengaluru – 59.**

*(An Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**Department of Mechanical Engineering**

**M. Tech. in Machine Design**

| SECOND SEMESTER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | | | | **Total Credits** |
| | | | | **Lecture L** | **Tutorial T** | **Practical P** | **Self-Study S** | |
| 1. | 16MEM21R | Research Methodology | IM | 3 | 1 | 0 | 0 | 4 |
| 2. | 16MMD22 | Theory of Mechanisms (Theory & Practice) | ME | 4 | 0 | 1 | 0 | 5 |
| 3. | 16MMD23X | Elective 2 | ME | 4 | 0 | 0 | 0 | 4 |
| 4. | 16MMD24X | Elective 3 | ME | 4 | 0 | 0 | 0 | 4 |
| 5. | 16MMD25X | Elective 4 | ME | 4 | 0 | 0 | 0 | 4 |
| 6. | 16MMD26 | Minor Project | ME | 0 | 0 | 5 | 0 | 5 |
| | | **Total** | | **19** | **1** | **6** | **0** | **26** |

| **Elective 2** | | | |
|---|---|---|---|
| 16MMD231 | Tribology and Bearing Design | 16MMD232/16MTE232 | Design of Hydraulics and Pneumatics |
| **Elective 3** | | | |
| 16MMD241 | Theory of Plates and Shells | 16MMD242/16MCM242 | Industrial Robotics |
| **Elective 4** | | | |
| 16MMD251 | Selection of Materials and Processes | 16MMD252 | Computer Applications in Design |

**R. V. College of Engineering, Bengaluru – 59.**

*(An Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**Department of Mechanical Engineering**

**M. Tech. in Machine Design**

| THIRD SEMESTER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | | | | **Credits** |
| | | | | **Lecture L** | **Tutorial T** | **Practical P** | **Self-Study S** | |
| 1 | 16MMD31 | Advanced Machine Design (Theory & Practice) | ME | 4 | 0 | 1 | 0 | 5 |
| 2 | 16MMD32X | Elective 5 | ME | 4 | 0 | 0 | 0 | 4 |
| 3 | 16MMD33X | Elective 6 | ME | 4 | 0 | 0 | 0 | 4 |
| 4 | 16MMD34X | Elective 7 | ME | 4 | 0 | 0 | 0 | 4 |
| 5 | 16MMD35 | Internship/Industrial Training | ME | 0 | 0 | 3 | 0 | 3 |
| 6 | 16MMD36 | Technical Seminar | ME | 0 | 0 | 2 | 0 | 2 |
| | | **Total** | | **16** | **0** | **6** | **0** | **22** |

| **Elective 5** | | | |
|---|---|---|---|
| 16MMD321 | Fracture Mechanics | 16MMD322 | Computational Fluid Dynamics |
| **Elective 6** | | | |
| 16MMD331 | Mechatronics system design | 16MMD332 | Rotor Dynamics |
| **Elective 7** | | | |
| 16MMD341 | Design of Smart Structures | 16MMD342 | Design of Pressure Vessels |

**R. V. College of Engineering, Bengaluru – 59.**

*(An Autonomous Institution Affiliated to Visvesvaraya Technological University, Belagavi)*

**Department of Mechanical Engineering**

**M. Tech. in Machine Design**

| FOURTH SEMESTER | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sl. No** | **Course Code** | **Course Title** | **BoS** | **CREDIT ALLOCATION** | | | | **Credits** |
| | | | | **Lecture L** | **Tutorial T** | **Practical P** | **Self-Study S** | |
| 1 | 16MMD41 | Major Project | ME | 0 | 0 | 26 | 0 | 26 |
| 2 | 16MMD42 | Seminar | ME | 0 | 0 | 2 | 0 | 2 |
| | | **Total** | | **0** | **0** | **28** | **0** | **28** |

| PROJECT MANAGEMENT | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16 MEM11P** | | **CIE Marks** | **:** | **100** |
| **Hrs/Week** | **:** | **L: T: P: S** | **3:2:0:0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **4** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives:**

Students are able to

1. Understand the principles and components of project management.
2. Appreciate the integrated approach to managing projects.
3. Elaborate the processes of managing project cost and project procurements.
4. Apply the project management tools and techniques.

**Unit – I** **7 Hours**

**Introduction:** Project, Project management, relationships among portfolio management, program management, project management, and organizational project management, relationship between project management, operations management and organizational strategy, business value, role of the project manager, project management body of knowledge.

**Unit – II** **8 Hours**

**Generation and Screening of Project Ideas:** Generation of ideas, monitoring the environment, corporate appraisal, scouting for project ideas, preliminary screening, project rating index, sources of positive net present value. Project costing,

**Project Scope Management:** Project scope management, collect requirements define scope, create WBS, validate scope, control scope.

**Organizational influences & Project life cycle:** Organizational influences on project management, project state holders & governance, project team, project life cycle.

**Unit – III** **7 Hours**

**Project Integration Management:** Develop project charter, develop project management plan, direct & manage project work, monitor & control project work, perform integrated change control, close project or phase.

**Project Quality management:** Plan quality management, perform quality assurance, control quality.

**Unit – IV** **7 Hours**

**Project Risk Management:** Plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk resources, control risk.

**Project Scheduling:** Project implementation scheduling, Effective time management, Different scheduling techniques, Resources allocation method, PLM concepts. Project life cycle costing.

**Unit-V** **7 Hours**

**Tools & Techniques of Project Management**: Bar (GANTT) chart, bar chart for combined activities, logic diagrams and networks, Project evaluation and review Techniques (PERT) Planning, Computerized project management.

**Syllabus includes tutorials for two hour per week:**

- Case discussions on project management
- Numerical problems on PERT & CPM
- Computerized project management exercises using M S Project Software

**Course Outcomes:**

After going through this course the student will be able to

CO1: Explain the process of project management and its application in delivering successful projects.

CO2: Illustrate project management process groups for various project / functional applications.

CO3: Appraise various knowledge areas in the project management framework.
CO4: Develop project plans and apply techniques to monitor, review and evaluate progress for different types of projects.

Reference Books:

1. Project Management Institute, "A Guide to the Project Management Body of Knowledge (PMBOK Guide)", 5th Edition, 2013, ISBN: 978-1-935589-67-9
2. Harold Kerzner, "Project Management A System approach to Planning Scheduling & Controlling", John Wiley & Sons Inc., 11th Edition, 2013, ISBN 978-1-118-02227-6.
3. Prasanna Chandra, "Project Planning Analysis Selection Financing Implementation & Review", Tata McGraw Hill Publication, 7th Edition, 2010, ISBN 0-07-007793-2.
4. Rory Burke, "Project Management – Planning and Controlling Techniques", John Wiley & Sons, 4th Edition, 2004, ISBN: 9812-53-121-1

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | M | M | ---- | M | H | H | H | ---- | H | ---- |
| **CO2** | ---- | M | ---- | ----- | M | H | H | H | L | H | ---- |
| **CO3** | --- | M | H | --- | M | H | H | H | H | H | M |
| **CO4** | M | H | M | L | H | H | H | H | ---- | H | H |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | | L |
| **CO2** | L | |
| **CO3** | L | L |
| **CO4** | | M |

| ADVANCED MATHEMATICS | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MAT12C** | | **CIE Marks** | : | **100** |
| **Hrs/Week** | **:** | **L-T-P-S:** | **4-0-0-0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **4** | | **SEE Duration** | **:** | **3 hrs** |

**Course Learning Objectives (CLO):**

The students shall be able to:

1. Identify and explain the basics of linear systems through matrix algebra and use the same to formulate and solve linear system of equations.
2. Recognise and apply the existing approximate methods for solving initial value, boundary value problems analytically and numerically.
3. Analyze concepts of vectors and tensors used in engineering applications.
4. Use probability concepts to recognize random physical phenomena and implement the proper model for predictions in mechanical engineering systems.

| **Unit – I** | **10 Hrs** |
|---|---|

**System of Equations and Eigen value problems**

Linear systems: Gauss elimination method, LU decomposition method, Matrix inversion, Ill-conditioned systems. Eigen values and eigen vectors, Jacobi method for symmetric matrices, Power method, Inverse Power method, Nonlinear algebraic equations: Newton-Raphson method.

| **Unit – II** | **10 Hrs** |
|---|---|

**Numerical Integration and Numerical Solutions of Ordinary Differential Equations**

Newton-Cotes methods, Romberg integration, Gaussian quadrature. Runge-Kutta method, Predictor-corrector methods, Problems with engineering applications.

| **Unit – III** | **09 Hrs** |
|---|---|

**Vector and Tensor Analysis**

Introduction to vector analysis, Tensor analysis: suffix notation, algebra of tensors, symmetric and skew symmetric tensors. Calculus of tensor: scalar, vector and tensor functions, gradient of a scalar and vector, divergence and curl of a vector and tensor.

| **Unit – IV** | **09 Hrs** |
|---|---|

**Numerical Solutions of Partial Differential Equations**

Finite difference method for elliptic, parabolic, hyperbolic equations, Solution of Laplace, Poisson and wave equations. Stability theory: Von-Neumann stability. Dirichlet and Neumann boundary conditions for the above partial differential equations.

| **Unit – V** | **10 Hrs** |
|---|---|

**Probability**

Random variables, discrete and continuous random variables, expectation, variance. Probability distribution: Binomial, Poisson and normal. Parameter estimation, Testing of hypothesis, Goodness of fit.

Experiential learning: MATLAB software tool to solve above said methods

**Course Outcomes:**

After going through this course the student will be able to:

**CO1**: Identify and interpret the fundamental concepts of vectors, tensors, matrices, numerical methods and probability.

**CO2**: Apply the knowledge and skills of statistical and numerical techniques to examine and solve different types of computational problems.

**CO3**: Analyze the physical problem to establish mathematical model and use appropriate

method to solve problems and optimize the solution.

**CO4**: Distinguish the overall mathematical knowledge gained to demonstrate and analyze the problems arising in practical situations.

**Reference Books:**


| | |
|---|---|
| 1. | M K Jain, S. R. K. Iyengar, R. K. Jain, "Numerical methods for scientific and engineering computation", New Age International Publishers, 6th edition, 2012, ISBN-13: 978-81-224-2001-2. |
| 2. | K. Sankara Rao, "Partial Differential Equations", Prentice-hall of India, 3rd edition, 2012, ISBN: 978-81-203-3217-1. |
| 3. | Seymour Lipschutz, Marc Lars Lipson, "Theory and Problems of Probability", Schaum's Outline Series, 2nd Edition, ISBN: 0-07-118356-6. |
| 4. | B. S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2015, ISBN: 978-81-7409-195-5. |


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | L | - | - | L | L | - | - | - | - | - | L |
| **CO2** | - | L | L | - | - | - | - | - | - | - | - |
| **CO3** | M | H | M | M | - | - | - | - | - | - | - |
| **CO4** | L | - | L | - | L | - | - | L | - | - | M |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | L | M |
| **CO2** | M | - |
| **CO3** | H | L |
| **CO4** | - | M |

| ADVANCED FINITE ELEMENT METHODS (Theory & Practice) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD13** | | **CIE Marks** | **:** | 100 + 50 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:1:0** | **SEE Marks** | **:** | 100 + 50 |
| **Credits** | **:** | **5** | | **SEE Duration** | **:** | **3 + 3 Hours** |

**Course Learning Objectives (CLO):**

Student are able to

- Identify mathematical model for solution of common engineering problems.
- Formulate simple problems into finite elements.
- Solve structural, thermal, fluid flow problems.
- Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.
- Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts.

| **Unit – I** | **12Hrs** |
|---|---|

**Finite Element Formulation of Boundary Value:** Solution to engineering problems – mathematical modeling – discrete and continuum modeling – need for numerical methods of solution – relevance and scope of finite element methods – engineering applications of FEA. Weighted residual methods –general weighted residual statement – weak formulation of the weighted residual statement –comparisons – piecewise continuous trial functions- example of a bar finite element –functional and differential forms – principle of stationary total potential – Rayleigh Ritz method – piecewise continuous trial functions – finite element method – application to bar element

| **Unit – II** | **10 Hrs** |
|---|---|

**One Dimensional Finite Element Analysis:** General form of total potential for 1-D applications – generic form of finite element equations – linear bar element – quadratic element –nodal approximation – development of shape functions – element matrices and vectors – example problems – extension to plane truss– development of element equations – assembly – element connectivity –global equations – solution methods –beam element – nodal approximation – shape functions – element matrices and vectors – assembly – solution – example problems.

| **Unit – III** | **12 Hrs** |
|---|---|

**Two Dimensional Finite Element Analysis:** Introduction – approximation of geometry and field variable – 3 noded triangular elements – four noded rectangular elements – higher order elements – generalized coordinates approach to nodal approximations – difficulties – natural coordinates and coordinate transformations – triangular and quadrilateral elements – iso-parametric elements – structural mechanics applications in 2-dimensions – elasticity equations – stress strain relations – plane problems of elasticity – element equations – assembly – need for quadrature formulae – transformations to natural coordinates – Gaussian quadrature – example problems in plane stress, plane strain and axisymmetric applications.

| **Unit – IV** | **8 Hrs** |
|---|---|

**Dynamic Analysis using Finite Element Method**: Introduction – vibrational problems – equations of motion based on weak form – longitudinal vibration of bars – transverse vibration of beams – consistent mass matrices – element equations –solution of eigenvalue problems – vector iteration methods – normal modes – transient vibrations – modeling of damping – mode superposition technique – direct integration methods.

**Applications in Heat Transfer & Fluid Mechanics:** One dimensional heat transfer element – application to one-dimensional heat transfer problems- scalar variable problems in 2-Dimensions – Applications to heat transfer in 2- Dimension – Application to problems in fluid mechanics in 2-D.

| **Unit – V** | **8 Hrs** |
|---|---|

**Axisymmetric elasticity problems**-Governing equations for Axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four node iso-parametric element.

**Three dimensional elasticity**-Governing differential equations, Four node tetrahedral element, Eight node hexahedral (brick) element, Twenty node isoparametric solid element, Pre stressing, initial strains and thermal effects.

**Unit - VI (Lab Component)** **24 Hours**

**Lab Exercises:**

1. Basic Stress analysis
2. Deflection and Stress Analysis in beams
3. Nonlinear plastic Deformation and buckling Analysis
4. Two dimensional problems (Plane stress & Plane strain problems)
5. Analysis of Composite materials
6. Analysis of pressure vessels
7. Three dimensional FE analysis
8. Contact Problems

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Demonstrate the basic concepts of finite element methods
CO2: Develop Finite Element Solutions in Structural, thermal and damping domains
CO3: Analyse systems for structural, thermal and damping
CO4: Create linear and non-linear Finite Element solutions

**Reference Books:**

1. Chandrupatla T. R., and Belegundu, A.D., "Introduction to Finite Elements in Engineering", Prentice Hall, 2003. *ISBN*-10: 0132162741
2. Reddy, J. N. "An Introduction to the Finite Element Method", 3rd Edition, McGraw-Hill Science/Engineering/Math, 2005. ISBN-10: 0072466855.
3. S. S. Rao "The Finite Element Methods in Engineering, Fifth Edition, Elsevier Publications. *ISBN*-9781856176613
4. Bathe, K.J., "Finite element procedures", Prentice Hall of India, New Delhi 2001, *ISBN* 620.00422.

**Scheme of Continuous Internal Evaluation (CIE) for Theory**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Continuous Internal Evaluation (CIE) for Practical**

CIE for the practical courses will be based on the performance of the student in the laboratory, every week. The laboratory records will be evaluated for 40 marks. One test will be conducted for 10 marks. The total marks for CIE (Practical) will be for 50 marks.

**Scheme of Semester End Examination (SEE) for Theory**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE) for Practical**

SEE for the practical courses will be based on conducting the experiments and proper results for 40 marks and 10 marks for viva-voce. The total marks for SEE (Practical) will be 50 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | H | - | M | H | M | - | - | - | - | - |
| **CO2** | M | - | M | L | - | - | - | - | - | - | - |
| **CO3** | - | - | H | - | M | - | - | - | - | - | - |
| **CO4** | - | M | - | M | - | H | L | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | M | L |
| **CO2** | - | M |
| **CO3** | M | - |
| **CO4** | H | H |

| ADVANCED THEORY OF VIBRATIONS | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD14** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:1** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **5** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives (CLO):**

Student are able to

1. Understand the principles of vibrations.
2. Examine the concepts of vibration modes and natural frequencies and their measurement and estimation for multi-degree-of-freedom systems.
3. Apply numerical techniques to obtain complete solution in Random & Non-linear vibrations.
4. Analyze vibration problems, signature analysis and interpretation of results.

| **Unit – I** | **10 Hrs** |
|---|---|

**Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency. Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation.

| **Unit – II** | **12 Hrs** |
|---|---|

**Vibration Control:** Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers. Vibration Measurement and applications : Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis

| **Unit – III** | **12 Hrs** |
|---|---|

**Modal analysis:** Dynamic Testing of machines and Structures, Experimental Modal analysis.
**Vibrations of beams:** equation of motion, modal analysis, approximate methods, initial value problem, forced vibrations, special problems, wave propagation Vibrations of membranes: equations of motion, modal analysis, approximate methods.
**Vibrations of plates:** equations of motion, modal analysis, approximate methods

| **Unit – IV** | **8 Hrs** |
|---|---|

**Random Vibrations :** Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response.

| **Unit – V** | **8 Hrs** |
|---|---|

**Signature analysis** and preventive maintenance, Vibration testing equipment, signal generation, measuring and conditioning instruments,
**Vibration testing equipment:** Signal analysis instruments, Vibration signatures and standards

**Self Study**

Each student has to select a topic of interest within the scope of the course and pursue study in that domain. This will be for 20 marks which will be evaluated in TWO phases by a committee consisting of two faculty members including the course faculty. The student has to demonstrate his/her capability of understanding, analyzing and applying the knowledge to solve problems. The study could be a theoretical one involving simulation and analysis or could be an experimental one or even involve building a prototype system.

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Construct Equations of motion based on free body diagrams
CO2: Analyse systems under free and forced vibrations for natural frequency of vibration
CO3: Evaluate Mechanical Systems using modal analysis
CO4: Develop solutions through testing for vibrations and signature analysis techniques

**Reference Books:**

1. S. Graham Kelly, "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007. *ISBN*-10: 1439062129
2. William T. Thomson, Marie Dillon Dahleh, "Theory of Vibration with Application", Prentice Hall Edition, *ISBN*, 0748743804, 2011
3. Sujatha, "Vibrations & Acoustics" – Tata McGraw Hill Edition**,** *ISBN*: *9780070148789, 2013*
4. S.S.Rao, "Mechanical Vibrations", Pearson Education, 4th ed. ISBN *978-0-13-212819-3, 2012*

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | - | H | L | - | M | - | - | - | - | - |
| **CO2** | - | M | - | H | L | - | - | - | - | - | - |
| **CO3** | H | - | H | - | - | L | - | - | - | - | - |
| **CO4** | - | M | - | M | H | - | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | - | L |
| **CO2** | M | - |
| **CO3** | - | M |
| **CO4** | H | H |

## ADVANCED SOLID MECHANICS
## (Elective Group – 1)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD151** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **4** | | **SEE Duration** | **:** | **3 Hours** |

Course Learning Objectives (CLO):
Student are able to

- Understand advanced stress/strain correlations in three dimensional bodies.
- Identify simple mathematical and physical relationships between mechanics and materials
- Evaluate the plastic behavior, fatigue, fracture and creep response of common engineering materials.
- Apply the knowledge to design the mechanical structures in the view point of both strength and deformation including the design by means of numerical simulation

| **Unit – I** | **12Hrs** |
|---|---|

**Introduction to general theory of elasticity:** assumptions and applications of linear elasticity. Analysis of stress, stress tensors. State of stress at a point, principal stresses in two dimensions, Cauchy's stress principle, direction cosines, stress components on an arbitrary plane with stress transformation. Principal stresses in three dimensions, stress invariants, Equilibrium equations, octahedral stresses, Mohr's stress circle, construction of Mohr's Circle for two and three dimensional stress systems, equilibrium equations in polar coordinates for three-dimensional state of stresses.

| **Unit – II** | **10 Hrs** |
|---|---|

**Introduction to analysis of strain**, types of strain, strain tensors, strain transformation. Principal strains, strain invariants, octahedral strains, Mohr's Circle for Strain, equations of Compatibility for Strain, strain rosettes. Stress-strain relations, generalised Hooke's law, compatibility conditions, transformation from Strain components to stress components. Strain energy in an elastic body, St. Venant's principle, uniqueness theorem

| **Unit – III** | **12 Hrs** |
|---|---|

**Theories of Failure and Energy Methods:** Introduction, Theories of Failure, Use of Factor of Safety in Design, Mohr's theory of Failure, Ideally Plastic Solid, Stress space and Strain space, General nature of Yield locus, Yield Surfaces of Tresca and Von Mises, Stress- Strain relation (Plastic Flow), Prandtl Reuss theory, Saint venant – Von mises equations.

Principle of Superposition, Reciprocal Relation, Maxwell-Betti-Rayleigh Reciprocal theorem, First theorem of Castigliano, Expressions for Strain Energy, Statically indeterminate structures, Theorem of Virtual Work, Second theorem of Castigliano. Maxwell – Mohr integrals.

| **Unit – IV** | **8 Hrs** |
|---|---|

**Bending of Beams:** Introduction, Straight beams and Asymmetrical Bending, Euler – Bernoulli hypothesis, Shear centre or Centre of Flexure, Shear stresses in thin walled open sections, Bending of curved beams, Deflection of thick curved bars.

| **Unit – V** | **8 Hrs** |
|---|---|

**Torsion:** Introduction, Torsion of general prismatic bars – Solid sections, Torsion of Circular and Elliptical bars, Torsion of equivalent triangular bar, Torsion of rectangular bars, Membrane analogy, Torsion of thin walled tubes, Torsion of thin walled multiple cell closed sections, Multiple connected sections, Centre of twist and flexure centre

**Course Outcomes**:

After going through this course the student will be able to:

CO1: Identify the stress strain relations in elastic and plastic conditions

CO2: Examine bodies subjected to three dimensional stresses for the onset of failure based on failure criteria

CO3: Analyse deflections in beams subjected to different types of loads in elastic, elastoplastic and plastic conditions

CO4: Evaluate stresses in bars subjected to torsion in elastic, elastoplastic and plastic conditions

**Reference Books**:


1. L. S. Srinath, "Advanced Mechanics of solids", , Tata Mc. Graw Hill, 2000, *ISBN*-13: 978-0070702608, 2009
2. S. P. Timoshenko "Theory of Elasticity", Mc. Graw Hill, 3rd edition, 1972 *ISBN* 978-0-13-223319-3
3. R A C Slater "Engineering Plasticity", The Mac Milan Press Ltd., 1st Edition, 1977, ISBN 978-1-349-02162-8
4. C.T. Wang "Applied Elasticity", Mc Graw Hill Book Co. *ISBN* 13: 9780070681255, 2003.


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | M | H | L | - | M | - | - | - | - | - |
| **CO2** | M | - | - | M | L | - | - | - | - | - | - |
| **CO3** | - | - | L | - | - | M | - | - | - | - | - |
| **CO4** | - | L | - | H | H | L | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | M | L |
| **CO2** | - | M |
| **CO3** | H | - |
| **CO4** | - | H |

| ACOUSTICS AND NOISE CONTROL (Elective Group – 1) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD152** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **4** | | **SEE Duration** | **:** | **3 Hrs** |

Course Learning Objectives (CLO):
Student are able to

1. Understand the basic concepts of acoustics and noise.
2. Apply the fundamentals of engineering acoustics for noise control practice.
3. Identify acoustic instruments for the use and application in noise control.
4. Evaluate basic acoustic parameters such as addition of noise sources, distance attenuation, room acoustic parameters.

| **Unit – I** | **8Hrs** |
|---|---|

**Introduction:** Acoustic and noise control, principles of noise reduction. Sound field dimensions, sound level calculation

| **Unit – II** | **10 Hrs** |
|---|---|

**Evolution and propagation of sound:** Simple oscillators, resonators, wave forms. Point emitters, geometrical acoustics, absorption, sound fields in rooms: room modes, statistical room acoustics, reverberation period, methods of simulation, and perceptive aspects in rooms. Airborne and body-borne sound insulation.

| **Unit – III** | **12 Hrs** |
|---|---|

**Sound measuring techniques and sound impacts:** Weighted sound pressure level ($L_A$, $L_B$, $L_C$), time constants (I, F, S), equivalent continuous sound level $L_{eq}$, SEL, TNI. Sound analysis with constant absolute bandwidth, spin sound. Third octave analysis, acoustic quieting extent, methods of calculation. Volume, loudness, annoyance, psycho-acoustical annoyance, speech interference level (SIL). Temporary threshold shift (TTS), permanent threshold shift (PTS).

| **Unit – IV** | **12 Hrs** |
|---|---|

**Human response to sound and vibration and psychoacoustics:** Human auditory system. Range of audible sound pressure levels and frequencies, infra sound, ultra sound. Pitch. Loudness: equal loudness contours and loudness level. Loudness calculations. Masking. Frequency weightings.

**Hearing disorders:** effects of age, health and noise exposure on hearing acuity. Individual noise susceptibility. Audiometry; basic procedures of manual and automatic audiometry; audiograms. Assessment of noise dose, hearing protectors and their use. Regulatory issues. Effects of noise and vibration on humans and human activity. Indices and methods of assessment of noise and vibration exposures.

| **Unit – V** | **8 Hrs** |
|---|---|

**Sound protection, regulations and codes:** Work noise (UVV Lärm, workplaces ordinance), machine noise, industrial noise (TA Lärm), street noise, train noise, aviation noise, noise from recreational activities.

**Course Outcomes:**
After going through this course the student will be able to:

CO1: Explain the principles of acoustics
CO2: Develop knowledge in the use of acoustic instruments for noise control analysis
CO3: Analyze the effects of vibrations and noise on human activities.
CO4: Apply codes and regulatory issues related to noise exposure

**Reference Books:**


1. R.J. Peters, B.J. Smith, Margaret Hollins, "Acoustics and Noise Control", *ISBN* 2-121-02527-7, 2010
2. Sujatha, Vibrations & Acoustics – Tata Mc Graw Hill**,** 2010, *ISBN*: *9780070148789*
3. Henirich Kuttruff "Acoustics - An Introduction" - Vikas Publishing House, New Delhi *ISBN10: 0415386802*, 2013
4. Moser, Michael, "Engineering Acoustics" Springer-Verlag, Berlin, *ISBN10 : 3642443710*


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | - | L | H | M | - | - | - | - | - | - |
| **CO2** | M | L | - | - | - | - | - | - | - | - | - |
| **CO3** | - | - | M | L | M | - | - | - | - | - | - |
| **CO4** | L | H | - | - | - | L | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | M | M |
| **CO2** | - | - |
| **CO3** | H | L |
| **CO4** | L | - |

| PROFESSIONAL SKILL DEVELOPMENT | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16HSS16** | | **CIE Marks** | **:** | **50** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:4:0** | **Credits** | **:** | **02** |

**Course Learning Objectives:**

Students are able to

1. Understand the importance of verbal and written communication
2. Improve qualitative and quantitative problem solving skills
3. Apply critical and logical think process to specific problems
4. Manage stress by applying stress management skills

| **UNIT 1** | **5 Hours** |
|---|---|

**Communication Skills:** Basics of Communication, Personal Skills & Presentation Skills, Attitudinal Development, Self Confidence, SWOC analysis.

Resume Writing: Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts.

| **UNIT 2** | **6 Hours** |
|---|---|

**Quantitative Aptitude and Data Analysis*:*** Number Systems, Math Vocabulary, fraction decimals, digit places etc. Reasoning and Logical Aptitude, - Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. Verbal Analogies – introduction to different question types – analogies, sentence completions, sentence corrections, antonyms/synonyms, vocabulary building etc. Reading Comprehension, Problem Solving

| **UNIT 3** | **4 Hours** |
|---|---|

**Interview Skills:** Questions asked & how to handle them, Body language in interview, Etiquette, Dress code in interview, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on Stress Interviews, Technical Interviews, General HR interviews

| **UNIT 4** | **5 Hours** |
|---|---|

**Interpersonal and Managerial Skills**: Optimal co-existence, cultural sensitivity, gender sensitivity; capability and maturity model, decision making ability and analysis for brain storming; Group discussion and presentation skills;

| **UNIT 5** | **4 Hours** |
|---|---|

**Motivation and Stress Management:** Self motivation, group motivation, leadership abilities Stress clauses and stress busters to handle stress and de-stress; professional ethics, values to be practiced, standards and codes to be adopted as professional engineers in the society for various projects**.**

**Note:** The respective departments should discuss case studies and standards pertaining to their domain

**Course Outcome:**

After going through this course the students will be able to

**CO1:** Develop professional skill to suit the industry requirement

**CO2:** Analyze problems using quantitative and reasoning skills

**CO3:** Develop leadership and interpersonal working skills

**CO4:** Demonstrate verbal communication skills with appropriate body language.

**References**

1. Stephen R Covey, “The 7 Habits of Highly Effective People”, Free Press, 2004 Edition, ISBN: 0743272455
2. Dale Carnegie, “How to win friends and influence people”, General Press, 1st Edition, 2016,

ISBN: 9789380914787
3. Kerry Patterson, Joseph Grenny, Ron Mcmillan, "Crucial Conversation: Tools for Talking When Stakes are High", McGraw-Hill Publication, 2012 Edition, ISBN: 9780071772204
4. Ethnus, "Aptimithra: Best Aptitude Book", Tata McGraw Hill, 2014 Edition, ISBN: 9781259058738

**Scheme of Continuous Internal Examination (CIE)**

Evaluation will be carried out in TWO Phases.

| Phase | Activity | Weightage |
|---|---|---|
| **I** | After 7 weeks - Unit 1, 2 & Part of Unit 3 | 50% |
| **II** | After 12 weeks – Unit 3, 4, 5 | 50% |

**CIE Evaluation shall be done with weightage as follows:**

| | |
|---|---|
| Writing skills | 10% |
| Logical Thinking | 25% |
| Verbal Communication & Body Language | 35% |
| Leadership and Interpersonal Skills | 30% |

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | --- | L | --- | ---- | H | ---- | H | H | H | M |
| **CO2** | H | M | H | --- | --- | --- | ----- | --- | M | H | M |
| **CO3** | --- | --- | L | --- | --- | H | --- | H | H | H | H |
| **CO4** | --- | --- | H | --- | ---- | H | L | H | H | H | H |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | | |
| **CO2** | | L |
| **CO3** | | |
| **CO4** | L | |

**II Semester**

| RESEARCH METHODOLOGY | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MEM21R** | | **CIE Marks** | **:** | **100** |
| **Hrs/Week** | **:** | **L: T: P: S** | **3:2:0:0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives:**

Students are able to

1. Understand of the underlying principles of quantitative and qualitative research
2. Perform the gap analysis and identify the overall process of designing a research study.
3. Choose the most appropriate research methodology to address a particular research problem
4. Explain a range of quantitative and qualitative approaches to analyze data and suggest possible solutions.

| **Unit – I** | **7 Hours** |
|---|---|

**Overview of Research**

Meaning of Research, Types of Research, Research and Scientific Method, Defining the Research Problem, Research Design, Different Research Designs.

| **Unit – II** | **7 Hours** |
|---|---|

**Methods of Data Collection**

Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Collection of Secondary Data, Selection of Appropriate Method for Data Collection.

| **Unit – III** | **8 Hours** |
|---|---|

**Sampling Methods**

Sampling process, Non-probability sampling, probability sampling: simple random sampling, stratified sampling, cluster sampling systematic random sampling, Determination of sample size, simple numerical problems.

| **Unit – IV** | **7 Hours** |
|---|---|

**Processing and analysis of Data**

Processing Operations, Types of Analysis, Statistics in Research, Measures of: Central Tendency, Dispersion, Asymmetry and Relationship, correlation and regression, Testing of Hypotheses for single sampling: Parametric (t, z and F) Chi Square, ANOVA, and non-parametric tests, numerical problems.

| **Unit-V** | **7 Hours** |
|---|---|

**Essential of Report writing and Ethical issues**:

Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Precautions for Writing Research Reports.

**Syllabus includes 12 hours of tutorials in which:**

- Faculty is expected to discuss research methodology for specializations under consideration.
- Numerical problems on statistical analysis as required for the domains in which students are studying must be discussed.
- Statistical analysis using MINITAB/ MatLab and such other softwares can be introduced.

**Course Outcomes:**

After going through this course the students will be able to

CO 1. Explain various principles and concepts of research methodology.

CO 2. Apply appropriate method of data collection and analyze using statistical methods.

CO 3. Analyze research outputs in a structured manner and prepare report as per the technical and ethical standards.

CO 4. Formulate research methodology for a given engineering and management problem situation.

**Reference Books:**

1. Kothari C.R., "Research Methodology Methods and techniques", New Age International, 2004, ISBN: 9788122415223
2. Krishnaswami, K.N., Sivakumar, A. I. and Mathirajan, M., "Management Research Methodology", Pearson Education India, 2009 Edition, ISBN:9788177585636
3. Levin, R.I. and Rubin, D.S., "Statistics for Management", 7th Edition, Pearson Education: New Delhi, ISBN-13: 978-8177585841

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | --- | --- | M | ---- | ---- | --- | H | --- | H | ----- |
| **CO2** | --- | L | H | H | M | M | L | L | ---- | M | L |
| **CO3** | L | M | M | M | H | M | L | M | --- | --- | M |
| **CO4** | H | H | H | H | ---- | L | L | M | H | --- | H |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | | |
| **CO2** | L | |
| **CO3** | M | M |
| **CO4** | | L |

| THEORY OF MECHANISMS (Theory & Practice) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD22** | | **CIE Marks** | **:** | 100 + 50 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:1:0** | **SEE Marks** | **:** | 100 + 50 |
| **Credits** | **:** | **05** | | **SEE Duration** | **:** | **3 + 3 Hours.** |

Course Learning Objectives (CLO):

Student are able to

1. Understand the fundamentals of machine design for desired kinematic or dynamic performance.
2. Determine the kinematic chain and mobility, and perform the kinematic analysis of a given mechanism.
3. Apply the fundamental principles of statics and dynamics to machinery
4. Identify the common dynamical problems that a machine may undergo

| **Unit – I** | **8Hrs** |
|---|---|

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

| **Unit – II** | **12 Hrs** |
|---|---|

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

| **Unit – III** | **12 Hrs** |
|---|---|

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

| **Unit – IV** | **8 Hrs** |
|---|---|

**Graphical Methods of Dimensional Synthesis**: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of 32 Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra.

| **Unit – V** | **8 Hrs** |
|---|---|

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

| Unit - VI (Lab Component) | 24 Hours |
|---|---|

Modeling and functional simulation of:

1. Freely falling body
2: Inclined Plane
3: Lift Mechanism - Geometry
4: Lift Mechanism - Simulation
5: One-degree-of-freedom Pendulum
6: Projectile
7: Spring Damper - Part 1
8: Spring Damper - Part 2
9: Suspension System 1
10: Suspension System 2
11: Four Bar Mechanism
12: Cam-Follower
13: Crank Slider
14: Controls Toolkit in ADAMS/View

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Describe the fundamental concepts of kinematics and dynamics
CO2: Design and analyze mechanism and kinematic linkages
CO3: Identify, formulate and solve engineering dynamic problems
CO4: Determine forces acting on the parts of machines used in Industries

**Reference Books:**


1. K.J.Waldron & G.L.Kinzel, "Kinematics, Dynamics and Design of Machinery", Wiley India, 2007. *ISBN*-10: 0471244171
2. Greenwood, "Classical Dynamics", Prentice Hall of India, 1988. *ISBN*-13: 978-0486696904
3. J E Shigley, "Theory of Machines and Mechanism" -McGraw-Hill, 1995, *ISBN*-12: 0471344276
4. A.G.Ambekar , "Mechanism and Machine Theory", PHI, 2007. *ISBN*: 978-81-203-3134-1


**Scheme of Continuous Internal Evaluation (CIE) for Theory**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Continuous Internal Evaluation (CIE) for Practical**

CIE for the practical courses will be based on the performance of the student in the laboratory, every week. The laboratory records will be evaluated for 40 marks. One test will be conducted for 10 marks. The total marks for CIE (Practical) will be for 50 marks.

**Scheme of Semester End Examination (SEE) for Theory**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE) for Practical**

SEE for the practical courses will be based on conducting the experiments and proper results for 40 marks and 10 marks for viva-voce. The total marks for SEE (Practical) will be 50 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | - | H | L | - | L | - | - | - | - | - | - |
| **CO2** | H | - | - | L | - | H | - | - | - | - | - |
| **CO3** | - | M | - | - | M | - | - | - | - | - | - |
| **CO4** | M | - | H | - | L | M | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | - | L |
| **CO2** | H | M |
| **CO3** | - | - |
| **CO4** | L | M |

**TRIBOLOGY AND BEARING DESIGN**
**(Elective Group – 2)**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD231** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours** |

Course Learning Objectives (CLO):
Student are able to

- Apply the basic theories of friction, wear and lubrication to predict the frictional behavior of commonly encountered sliding interfaces.
- Understand the principles of bearing selection and bearing arrangement in machines.
- Apply the principles of high contact stresses (Hertz stresses), fatigue-failure, and Elastohydrodynamic (EHD) lubrication in rolling bearings and gears.
- Identify the tribological system for optimal performance

**Unit – I** **8Hrs**

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

**Unit – II** **12 Hrs**

**Hydrodynamic Lubrications:** Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of centre of pressure, effect of end leakage on performance, Numerical problems.
**Journal Bearings:** Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Somerfield number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems..

**Unit – III** **12 Hrs**

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

**Unit – IV** **8 Hrs**

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

**Unit – V** **8 Hrs**

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

**Course Outcomes**:

After going through this course the student will be able to:
CO1: Demonstrate fundamentals of tribology, lubricants and methods of lubrication
CO2: Analyze bearings for load carrying capacity, frictional force and power loss
CO3: Illustrate the different modes of lubrication system for various applications.
CO4: Design the bearing system for various type of viscosity of the lubricant with respect to temperature and pressure in the bearing

**Reference Books:**


1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001, *ISBN* 0-471-65659-3
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000, *ISBN* 5-341-43736-1
3. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970, *ISBN* 10-481-34631-2
4. Harnoy, A. "Bearing Design in Machinery, Engineering Tribology and lubrication", published by Marcel Dekker Inc. 2003, *ISBN* 0-8247-0703-6


.**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | M | L | - | M | - | L | - | - | - | - |
| **CO2** | - | H | - | M | - | H | - | - | - | - | - |
| **CO3** | - | - | M | - | - | - | - | - | - | - | - |
| **CO4** | M | M | L | M | H | - | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | M | L |
| **CO2** | L | - |
| **CO3** | - | M |
| **CO4** | H | H |

| DESIGN OF HYDRAULICS AND PNEUMATICS (Elective Group – 2) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD232/16MTE232** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives (CLO):**

Students are able to

- Identify the symbolic representation of hydraulic systems
- Understand the working of industrial systems employing fluid power
- Identify the working of hydraulic circuits
- Select the appropriate components through design calculations and Demonstrate the electronic components in pneumatic systems.

**Unit – I** **10 Hrs**

**Hydraulic Actuators and Motors:** Pascal's law and problems on Pascal's Law, continuity equations, introduction to conversion of units. Structure of Hydraulic Control System Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder loading, Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, and hydraulic motor performance.

**Unit – II** **10 Hrs**

**Control Components in Hydraulic Systems:** Directional Control Valves – Symbolic representation, Constructional features, pressure control valves – direct and pilot operated types, flow control valves.

**Hydraulic Circuit Design and Analysis:** Control of single and double – acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Double pump Hydraulic system, Counter Balance Valve application, and Hydraulic cylinder sequencing circuits. Locked cylinder using pilot check valve, cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, accumulators and accumulator circuits.

**Unit – III** **10 Hrs**

**Introduction to Pneumatic Control:** Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system. Pneumatic Actuators: Linear cylinders – Types, conventional type of cylinder working, end position cushioning, seals, mounting arrangements applications. Rod–less cylinders, types, working advantages. Rotary cylinder types construction and application. Design parameters, selection.

**Unit – IV** **08 Hrs**

**Directional Control Valves:** Symbolic representation as per ISO 1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling use of quick exhaust valve. Signal processing elements: Use of Logic gates – OR and AND gates pneumatic applications. Practical examples involving the use of logic gates. Pressure dependent controls types construction–practical applications. Time dependent controls – Principle, construction, practical applications.

**Unit – V** **10 Hrs**

**Multi-cylinder Applications:** Coordinated and sequential motion control. Motion and control diagrams – Signal elimination methods. Cascading method – principle. Practical application examples (up to two cylinders) using cascading method (using reversing valves). Electro-Pneumatic control: Principles-signal input and output pilot assisted solenoid control of directional

control valves, use of relay and contactors. Control circuitry for simple single cylinder applications. Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, Filters, Regulators, Distribution of compressed air- Piping layout.

**Course Outcomes:**

**After going through this course the student will be able to:**

CO1 Illustrate and explain the significance hydraulic and pneumatic components
CO2 Describe the symbolic representations of fluid power components in an industrial circuit.
CO3 Evaluate the selection of valves for specific applications
CO4 Design and develop hydraulic and pneumatic based system for industrial applications.

**Reference Books:**

1. Anthony Esposito Fluid Power with applications, Fifth edition Pearson education, Inc. 2000. ISBN- 10: 129202387
2. Andrew Parr Pneumatics and Hydraulics. Jaico Publishing Co. 2000. ISBN- 10: 0750644192
3. S.R. Majumdar Oil Hydraulic Systems - Principles and Maintenance, Tata Mc Graw Hill publishing company Ltd. 2001. ISBN- 10: 0074637487
4. S.R. Majumdar Pneumatic Systems, Tata Mc Graw Hill publishing Co., 1995. ISBN-0074602314.

**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | - | - | - | - | - | - | - | - | - | - |
| **CO2** | - | H | M | M | M | - | - | - | - | - | - |
| **CO3** | - | - | M | M | - | - | - | - | - | - | - |
| **CO4** | H | M | L | - | H | - | L | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | L | L |
| **CO2** | M | - |
| **CO3** | - | L |
| **CO4** | L | H |

| THEORY OF PLATES AND SHELLS (Elective Group – 3) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD241** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours** |

Course Learning Objectives (CLO):
Student are able to

- Understand the classical structural mechanics approximations of Membrane, Plate and Shell theories.
- Apply energy formulations to demonstrate the consistent derivation of approximate boundary conditions and edge effects.
- Identify the necessary tools to describe static, dynamic and non-linear motions.
- Evaluate the buckling, vibration and stress parameters in thin shells using numerical approximation techniques.

| **Unit – I** | **8Hrs** |
|---|---|

**General Introduction:** Review of equations of elasticity- kinematics, compatibility equations, stress measures- equations of motions- constitutive relations- transformation of stresses, strains and stiffness-energy principles and variational methods in elasticity- virtual work-external and internal virtual work variational operator- functionals- Euler Lagrange equations- energy principles- Hamilton's principle- principle of minimum total potential- applications.

| **Unit – II** | **12 Hrs** |
|---|---|

**Classical Theory Of Plates:** Plates as structural elements- stress and moment resultants- assumptions made in the classical theory- displacement fields and strains- equations of equilibrium in Cartesian coordinates and in polar coordinates- boundary conditions – bending of rectangular plates with various boundary conditions and loading- symmetrical and asymmetrical bending of circular plates-limitations of classical theory- finite element analysis

| **Unit – III** | **12 Hrs** |
|---|---|

**Buckling Analysis of Rectangular Plates:** Buckling of simply supported plates under compressive forces- governing equations- the Navier solution- biaxial compression of a plate- uniaxial compression of a plate- buckling of plates simply supported on two opposite edges- Levy's solution- buckling of plates with various boundary conditions- general formulation- finite element analysis

| **Unit – IV** | **8 Hrs** |
|---|---|

**Vibration of Plates:** Governing equations for natural flexural vibrations of rectangular plates- natural vibrations of plates simply supported on all edges- vibration of plates with two parallel sides simply supported Levy's solution- vibration of plates with different boundary conditions- Rayleigh-Ritz method Natural vibration of plates with general boundary conditions- transient analysis of rectangular plates- finite element analysis

| **Unit – V** | **8 Hrs** |
|---|---|

**Analysis of Thin Elastic Shells of Revolution:** Classification of shell surfaces- geometric properties of shells of revolution- general strain displacement relations for shells of revolution- stress resultants- equations of motion of thin shells, analytical solution for thin cylindrical shells- membrane theory- flexure under axisymmetric loads, shells with double curvature- geometric considerations- equations of equilibrium- bending of spherical shells- vibration of cylindrical

shells- finite element analysis.

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Apply the structural mechanics approximations of membrane, plates and shells.

CO2: Develop simple modifications to the membrane plate and shell theories

CO3: Describe the static, dynamic, and non-linear motion of membrane, plate and shell structures.

CO4: Analyze numerical problems in shells of revolution

**Reference Books:**


1. Reddy,J.N., "Theory and Analysis of Elastic Plates & Shells", C.R.C. Press, NY, USA, 2nd Edition, *ISBN* 9780849384158
2. Szilard, R., Theory and Analysis of Plates, Prentice Hall Inc., 1999, *ISBN* 0-12-9353336-2
3. Timoshenko, S. and Krieger S.W. Theory of Plates and Shells, McGraw Hill Book Company, New York 1990, *ISBN* 0-13-913426-3
4. Wilhelm Flügge, Stresses in shells, Springer –Verlag, *ISBN* 978-3-662-01028-0


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | H | L | - | - | - | - | - | - | - |
| **CO2** | - | - | - | M | - | L | - | - | - | - | - |
| **CO3** | H | L | L | - | - | - | - | - | - | - | - |
| **CO4** | L | M | - | H | H | L | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | M | L |
| **CO2** | L | - |
| **CO3** | - | M |
| **CO4** | H | H |

| INDUSTRIAL ROBOTICS (Elective Group – 3) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD/MCM242** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours.** |

**Course Learning Objectives (CLO):**

Students are able to

1. Understand the structure and configuration of Industrial robots.
2. Analyze the kinematic and dynamic related analysis of industrial robots.
3. Demonstrate the basic structure of trajectory interpolator
4. Describe the configuration of various types of autonomous robots

| **Unit – I** | **07Hrs** |
|---|---|

**Automation and Robotics -** Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Control Approaches of Robots

| **Unit – II** | **10Hrs** |
|---|---|

**Kinematics of Robot Manipulator**: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation

| **Unit – III** | **12Hrs** |
|---|---|

**Robotic Workspace & Motion Trajectory**: Introduction, General Structures of Robotic Workspaces, Manipulations with n Revolute Joints, Robotic Workspace Performance Index, Extreme Reaches of Robotic Hands, Robotic Task Description. Robotic Motion Trajectory Design: – Introduction, Trajectory Interpolators, Basic Structure of Trajectory Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories: 4-3-4 & 3-5-3 Trajectories, Admissible Motion Trajectories.

| **Unit – IV** | **12Hrs** |
|---|---|

**Dynamics of Robotic Manipulators**: Introduction, Bond Graph Modeling of Robotic Manipulators, Examples of Bond Graph Dynamic Modeling of Robotic Manipulator. Brief Discussion on Lagrange–Euler (LE) Dynamic Modeling of Robotic Manipulators: - Preliminary Definitions, Generalized Robotic Coordinates, Dynamic Constraints, Velocity & Acceleration of Moving Frames, Robotic Mass Distribution & Inertia Tensors, Newton's Equation, Euler Equations, The Lagrangian & Lagrange's Equations. Application of Lagrange–Euler (LE) Dynamic Modeling of Robotic Manipulators: - Velocity of Joints, Kinetic Energy T of Arm, Potential Energy V of Robotic Arm, The Lagrange L, Two Link Robotic Dynamics with Distributed Mass, Dynamic Equations of Motion for A General Six Axis Manipulator.

| **Unit – V** | **07Hrs** |
|---|---|

**Autonomous Robot**: Locomotion Introduction, Key issues for locomotion Legged Mobile Robots Leg configurations and stability Examples of legged robot locomotion Wheeled Mobile Robots Wheeled locomotion: the design space Wheeled locomotion: case studies Mobile Robot Kinematics Introduction Kinematic Models and Constraints Representing robot position Forward kinematic models Wheel kinematic constraints Robot kinematic constraints, Mobile Robot

Maneuverability Degree of mobility Degree of steerability Robot maneuverability.

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Analyze the manipulator design including actuator, drive and sensor issues
CO2: Calculate the forward kinematics, inverse kinematics and Jacobian industrial robots
CO3: Solve trajectory and dynamic related robotic problems
CO4: Evaluate the different configurations and stability of autonomous robots

**Reference Books:**


1. Mohsen Shahinpoor "A Robot Engineering Textbook" Harper & Row publishers, New York.ISBN:006045931X
2. Fu, Lee and Gonzalez, "Robotics, control vision and intelligence," McGraw Hill International.ISBN:0070226253
3. John J. Craig, "Introduction to Robotics", Addison Wesley Publishing, ISBN:0201543613
4. Roland Illah R. SiegwartNourbakhsh, Autonomous mobile robots, The MIT Press Cambridge, Massachusetts London, England, 2004.ISBN:0262015358


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | - | - | - | - | - | L | - | - | - | - |
| **CO2** | - | H | M | M | - | - | - | L | - | - | - |
| **CO3** | - | H | M | M | - | - | - | L | - | - | - |
| **CO4** | - | - | - | - | - | - | L | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | L | L |
| **CO2** | M | - |
| **CO3** | - | L |
| **CO4** | L | H |

| SELECTION OF MATERIALS AND PROCESSES (Elective Group – 4) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code:** | **:** | **16MMD251** | | **CIE Marks** | **:** | 100 |
| **Hours /Week:** | **:** | **L:T:P:S** | **4:0:0:0** | **SEE Marks** | **:** | 100 |
| **Credit** | **:** | **04** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives (CLO)**

Students are able to

(1) Understand the properties of different materials and composites

(2) Identify the manufacturing process based on material and product

(3) Distinguish between processes for polymers, metals and ceramics

(4) Evaluate the design considerations based on material & process

**Unit - I** **10Hrs**

**Thermoplastic Polymers & Its Manufacturing Processes**

Polyethylene, Polypropylene, Polystyrene, Polyester, Polyvinyl Chloride, Acrylic, Polyamides, Polycarbonates, Review of Properties, Extrusion process, injection molding process, compression molding and blow molding process, Applications of thermoplastics

**Unit – II** **10Hrs**

**Thermoset Polymers & Manufacturing Processes for Composites**

Epoxy resins, Polyester Resins, Vinyl Esters Resin, High Temperature Resin systems (PMR-15), Hand layup, Vacuum Bagging, Thermal Curing, Resin Transfer Mouding, Auto-Clave Filament winding and pultrusion Process

**Micro & Macro Mechanical Analysis**

Rule of mixture- density, Poisson ratio, Lateral and Longitudinal Modulus, Ultimate Tensile Strength, Compliance and Stiffness matrix for 2D lamina, and angle lamina, design considerations for selection of material and process, numericals

**Unit – III** **10Hrs**

**Die Casting Processes**

Die casting alloys, classification of castings, hot and cold chamber pressure die casting, investment casting, horizontal and vertical machines, feed system layout, Single and multicavity moulds, inspection of casting, defects in castings, numerical on mould design

**Powder Metallurgy Processes**

Metallic powders – synthesis – ball milling, spray process, atomization, and characterization, preparation of green compact, pressure less and pressure-assisted sintering, finishing process, applications of PM, numerical on PM mould design,

**Unit – IV** **10Hrs**

**Ceramic Materials & Processing Technologies**

Ceramic materials - Silicate & Non-silicate Ceramics, Alumina, Zirconia; Pressing, casting, extrusion of ceramics, role of additives, industrial, domestic and medical applications of ceramics

**Unit – V** **9Hrs**

**Materials & Process for Design**

Introduction, Nature of the Selection Process, Analysis of the Material Performance Requirements and Creating Alternative Solutions, Initial Material Screening of Solutions, Comparing and Ranking Alternative Materials, Design Considerations for Cast Components, Molded Plastic Components, Powder Metallurgy Parts, Detail Design and Selection of Materials and Processes.

**Course Outcomes**

CO1: Explain the manufacturing process involved thermoplastic, thermoset and ceramic

materials

CO2: Apply rule of mixtures to evaluate mechanical properties of composites

CO3: Describe die casting and powder metallurgy processes

CO4: Evaluate the design considerations based on material & process

**Reference Books:**


1. Autar Kaw, "Mechanics of Composite Materials", Taylor & Francis, *ISBN* 8870-1-118-02227-6.
2. Fred Billyer, "Text Book on Polymer Science" ,3rd Edition, Wiley Publication, *ISBN* 54-1-118-27-4
3. A K Sinha, "Powder Metallurgy", 2nd Edn, Dhanpath Rai Publications, *ISBN* 1-118-04527-6.
4. Do Ehler H A, "Die Casting", McGraw Hill Publications, *ISBN* 1056-1-118-06.


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | L | - | M | - | - | - | - | - | - |
| **CO2** | - | L | M | M | - | M | - | - | - | - | - |
| **CO3** | L | | | L | M | - | - | - | - | - | - |
| **CO4** | - | M | L | L | - | H | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | L | L |
| **CO2** | - | - |
| **CO3** | H | M |
| **CO4** | L | - |

| COMPUTER APPLICATIONS IN DESIGN (Elective Group – 4) | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MMD252** | | **CIE Marks** | **:** | 100 |
| **Hrs/Week** | **:** | **L:T:P:S** | **4:0:0:4** | **SEE Marks** | **:** | 100 |
| **Credits** | **:** | **04** | | **SEE Duration** | **:** | **3 Hrs** |

**Course Learning Objectives (CLO):**

Graduates shall be able to

1. Memorize the equations of transformations, curves, solid models and surfaces
2. Understand the concept of computer Graphics
3. Demonstrate the principles of wire frame, Geometric, and surface modeling
4. Distinguish the different concepts of algorithm

| **Unit – I** | **08 Hrs** |
|---|---|

**Computer Graphics:** Line drawing algorithms: DDA, Bresenham's algorithms, Mid-point circle algorithms, coordinate systems, windowing, View generation, Clipping, Transformations of geometry.

| **Unit – II** | **12 Hrs** |
|---|---|

**Software Configuration:** Software configuration of a graphics system, Functions of a graphics package, Mathematics of projections, Hidden line removal, Hidden surface removal, Shading, Rendering.

**Basics of geometry modeling:** Requirements of geometric modeling, geometric models, geometric construction methods, modeling facilities desired.

| **Unit – III** | **12 Hrs** |
|---|---|

**Wireframe Modeling:** Classification of wire frame entities, curve representation methods, parametric representation of analytic curves, curvature continuity, Lagrange interpolation, Parametric representation of synthetic curves, curve manipulations.

| **Unit – IV** | **8 Hrs** |
|---|---|

**Solid Modeling:** Application of solid models, modeling considerations of solids, geometry and topology, solid modeling scheme, Boundary Representation, Winged edge data structure for Boundary representation, Euler operations, Constructive solid geometry, Sweeping, Solid Manipulations.

| **Unit – V** | **08 Hrs** |
|---|---|

**Surface modeling:** Introduction, Planes, Vector Planes, surface entities, Surface representation methods, Quadratic Surface in normal forms, Quadratic Surface in general forms, Quadratic Surface in matrix form, parametric surfaces, Parametric representation of analytic surfaces, Parametric representation of synthetic surfaces, Surface Manipulations.

**Course Outcomes:**

After going through this course the student will be able to:

CO1: Discuss the concepts of Computer Graphics in CAD in product development
CO2: Apply the concepts of CAD in the manufacturing industry
CO3: Analyze the concepts of computer Aided Design
CO4: Evaluating the techniques involved in CAD.

**Reference Books:**


1. Chennakesava R Alavala "CAD/CAM Concepts and Applications", 1st Ed PHI, New Delhi, 2009 ISBN 978-81-203-3340-6
2. P.N. Rao, "CAD/CAM Principles and Applications", 3rd Ed., McGraw Hill, Education Pvt Ltd., New Delhi ISBN 0-07-058373-0
3. Ibrahim Zeid, "Mastering CAD/CAM" , 2nd Ed., TMH Publishing Company Limited., New Delhi, ISBN 0-07-0634334-3
4. M.P. Groover and 3 E W Zimmers, CAD/CAM Computer aided Design and Manufacturing, 9th Ed, 1993, ISBN 81-203-0402-0


**Scheme of Continuous Internal Evaluation (CIE)**

CIE will consist of TWO Tests, TWO Quizzes and ONE assignment. The test will be for 30 marks each and the quiz for 10 marks each. The assignment will be for 20 marks. The total marks for CIE (Theory) will be 100 marks.

**Scheme of Semester End Examination (SEE)**

The question paper will have FIVE questions with internal choice from each unit. Each question will carry 20 marks. Student will have to answer one question from each unit. The total marks for SEE (Theory) will be 100 marks.

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | L | H | - | - | - | - | - | - | - | - |
| CO2 | H | M | M | L | - | - | - | - | - | - | - |
| CO3 | L | H | - | H | M | - | - | - | - | - | - |
| CO4 | - | - | L | M | H | L | - | - | - | - | - |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| CO1 | H | - |
| CO2 | M | L |
| CO3 | L | M |
| CO4 | - | H |

| MINOR PROJECT | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **:** | **16MCM26** | | **CIE Marks** | **:** | **100** |
| **Hrs/Week** | **:** | **L:T:P:S** | **0:0:10:0** | **SEE Marks** | **:** | **100** |
| **Credits** | **:** | **05** | | **SEE Duration** | **:** | **3 Hours** |

**Course Learning Objectives:**

Students are able to

1. Understand the method of applying engineering knowledge to solve specific problems.
2. Apply engineering and management principles while executing the project
3. Demonstrate the skills for good presentation and technical report writing skills.
4. Identify and solve complex engineering problems using professionally prescribed standards.

**GUIDELINES**

1. Each project group will consist of maximum of two students.
2. Each student / group has to select a contemporary topic that will use the technical knowledge of their program of study after intensive literature survey.
3. Allocation of the guides preferably in accordance with the expertise of the faculty.
4. The number of projects that a faculty can guide would be limited to four.
5. The minor project would be performed in-house.
6. The implementation of the project must be preferably carried out using the resources available in the department/college.

**Course Outcomes:**

After going through this course the students will be able to

**CO1:** Conceptualize, design and implement solutions for specific problems.

**CO2:** Communicate the solutions through presentations and technical reports.

**CO3:** Apply resource managements skills for projects

**CO4:** Synthesize self-learning, team work and ethics.

**Scheme of Continuous Internal Examination (CIE)**

Evaluation will be carried out in THREE Phases. The evaluation committee will comprise of FOUR members : guide, two senior faculty members and Head of the Department.

| Phase | Activity | Weightage |
|---|---|---|
| **I** | Synopsis submission, Preliminary seminar for the approval of selected topic and Objectives formulation | 20% |
| **II** | Mid-term seminar to review the progress of the work and documentation | 40% |
| **III** | Oral presentation, demonstration and submission of project report | 40% |

****Phase wise rubrics to be prepared by the respective departments**

**CIE Evaluation shall be done with weightage / distribution as follows:**

- Selection of the topic & formulation of objectives 10%
- Design and simulation/ algorithm development/experimental setup 25%
- Conducting experiments / implementation / testing 25%
- Demonstration & Presentation 15%
- Report writing 25%

**Scheme for Semester End Evaluation (SEE):**

The evaluation will be done by ONE senior faculty from the department and ONE external faculty member from Academia / Industry / Research Organization. The following weightages would be given for the examination. Evaluation will be done in batches, not exceeding 6 students.

1. Brief write-up about the project 5%
2. Presentation / Demonstration of the project 20%
3. Methodology and Experimental Results & Discussion 25%
4. Report 20%
5. Viva Voce 30%

**Mapping of Course Outcomes (CO) to Program Outcomes (PO)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | H | H | H | --- | --- | M | --- | H | H |
| **CO2** | ---- | --- | ---- | --- | H | ---- | --- | H | H | H | ---- |
| **CO3** | H | H | M | --- | M | M | H | H | --- | M | H |
| **CO4** | --- | H | ---- | --- | ---- | H | M | M | M | H | --- |

**Mapping of Course Outcomes (CO) to Program Specific Outcomes (PSO)**

| | PSO1 | PSO2 |
|---|---|---|
| **CO1** | H | M |
| **CO2** | | L |
| **CO3** | | M |
| **CO4** | M | M |