| Semester: III | | |
|---|---|---|
| Mathematics for Mechanical Engineers | | |
| Course Code: | MVJ22MME31 | CIE Marks: 50 |
| Credits: | L: T:P:S: 2:2:0:0 (3) | SEE Marks: 50 |
| Hours: | 40 (L+T) | SEE Duration: 3 Hrs. |
| Course Learning Objectives: The students will be able to | | |
| 1 | Use of statistical methods in curve fitting applications. | |
| 2 | Understand the concepts of Complex variables and transformation for solving Engineering Problems. | |
| 3 | Solve the linear differential equations using Laplace transforms. | |
| 4 | Apprehend and apply Fourier Series. | |
| 5 | Demonstrate Fourier Transform as a tool for solving Integral equations. | |

| UNIT-I | |
|---|---|
| **Statistical Methods:** Introduction, Correlation and coefficient of correlation, Regression, lines of regression and problems.<br>**Curve fitting:** Curve fitting by the method of least squares. Fitting of the curves of the form $y = ax + b$, $y = ax^2 + bx + c$, $y = ae^{bx}$ .<br>**Self study:** Fitting of the curves of the form $\boldsymbol{y = ax^b}$.<br>**Web Link and Video Lectures:**<br>https://nptel.ac.in/courses/111105042 | 8 Hrs |
| **UNIT-II** | |
| **Complex Variables:** Functions of complex variables, Analytic function, Cauchy-Riemann equations in Cartesian and polar coordinates, Construction of analytic function (Using Milne-Thomson method)<br>Consequences of Cauchy-Riemann equations, Properties of analytic functions.<br>Application to flow problems- complex potential, velocity potential, equipotential lines, stream functions, stream lines.<br>**Self-study:** Unique Expression Method<br>**Applications:** Application to flow problems<br>**Video Link:**<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | 8 Hrs |
| **UNIT-III** | |
| **Laplace Transform:** Definition and Laplace transforms of elementary | 8 Hrs |

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|---|---|
| functions. Laplace transforms of Periodic functions and unit-step function and problems.<br><br>**Inverse Laplace Transform:** Definition and problems, Convolution theorem to find the inverse Laplace transforms and problems.<br>**Applications**: Solution of linear differential equations using Laplace transforms.<br>**Self study:** Derivations of Laplace transforms of elementary functions, Unit impulse function-problems.<br><br>**Web Link and Video Lectures:**<br><br>https://nptel.ac.in/courses/111106139 | |
| UNIT-IV | |
| **Fourier Series:** Periodic functions, Dirichlet's condition, Fourier series of periodic functions with period $2\pi$ and arbitrary period $2c$. Fourier series of even and odd functions. Half range Fourier Series, Practical harmonic Analysis and Problems.<br>**Self study:** Complex form of Fourier series.<br>**Applications**: The Fourier series has many such applications in harmonic analysis, vibration analysis,acoustics, optics etc.<br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | 8 Hrs |
| UNIT-V | |
| **Fourier Transforms:** Infinite Fourier transform, Infinite Fourier sine and cosine transforms, Inverse Fourier transforms, Inverse. Fourier sine and cosine transforms, Convolution theorem<br><br>**Self-study:** Complex form of Fourier series.<br>**Applications:** Fourier transforms used in image<br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | 8 Hrs |

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| Course Outcomes: After completing the course, the students will be able to |

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|---|---|
| CO1 | Fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data. |
| CO2 | Use the concepts of analytic function and complex potentials to solve the problems arising in electromagnetic field theory. |
| CO3 | Use Laplace transform and inverse transforms techniques in solving differential equations. |
| CO4 | Know the use of periodic signals and Fourier series to analyze circuits and system. |
| CO5 | Demonstrate Fourier Transform as a tool for solving Integral equations. |

| Reference Books | |
|---|---|
| 1. | B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 44th Edition, 2013. |
| 2. | Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10thedition, 2014. |
| 3. | Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition |
| 4. | Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006. |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to

answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO2 | 3 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 3 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO4 | 3 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO5 | 3 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

| Semester: III | | |
|---|---|---|
| ENGINEERING THERMODYNAMICS<br>(Theory) | | |
| Course Code: MVJ22ME32 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40L | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |

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|---|---|
| 1 | To be able to learn and understand basic concepts & definitions of thermodynamics |
| 2 | To be able to use the First and Second Law of Thermodynamics to estimate thermo-mechanical energy conversion and performance parameters |
| 3 | To be able to learn the Concept of Entropy and apply thermodynamics principles to air standard cycles with the help of PV and Ts diagrams |
| 4 | To be able to learn concepts of IC engines, Calculations of BP, IP, Mechanical efficiency, Heat balance sheet |
| 5 | Performance analysis of R.A.C and optimization of compression. |

| UNIT-I | |
|---|---|
| **Fundamental Concepts & Definitions**: Introduction to Thermodynamics; definitions thermodynamics, concepts of thermodynamics, Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium- Zeroth law of thermodynamics, Temperature; concepts, scales, measurement<br>**Work & Heat**: Definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units, and sign convention.<br>**Experiential Learning**: IC Engines, Thermometers, Dynamometer, Compressors etc.<br>**Video Links/Any other special information**:<br>1. https://www.youtube.com/watch?v=WFMIzS2jQQg&t=48s<br>2. https://nptel.ac.in/courses/112105123 | 8 Hrs |
| UNIT-II | |
| **First Law of Thermodynamics**: Joule's experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non -cyclic processes, energy, energy as a property, modes of energy, Specific heat at constant volume, enthalpy, specific heat constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications.<br>**Experimental learning:** First law for open system- ( Use HMT Lab heat exchanger) • Flow hot water through tubes, find the inlet temperature of water and outlet temperature of water. With the help of steam table find inlet and outlet enthalpy for the corresponding temperature. Use steady flow energy equation and continuity equation find the mass flow rate of water • Making Model for Perpetual Motion Machine (PMM1) _ Group activity<br>**Video Links/Any other special information**:<br>1. http://www.youtube.com/watch<br>2. https://nptel.ac.in/courses/112104113/ | 8 Hrs |
| UNIT-III | |
| **Second Law of Thermodynamics**: Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir. Direct heat engine; schematic representation and efficiency. Reserved heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamic; PMM I & PMM II . Clasius's statement of Second law of | 8 Hrs |

| | |
|---|---|
| Thermodynamic; Equivalence of the two statements; Reversible and irreversible processes; factors that make a process irreversible, reversible heat engine, Carnot cycle, Carnot principles. Thermodynamic temperature scale.<br>**Experiential Learning**: Compressors, Turbines, IC engines, Refrigerator, Heat Pump etc<br>**Video link / Additional online information**:<br>1. https://www.youtube.com/watch?v=10FlW80XN64<br>2. https://nptel.ac.in/courses/112104113/<br>3. https://www.youtube.com/watch?v=cobFAMZDS0o<br>4. https://nptel.ac.in/courses/112108148/ | |
| UNIT-IV | |
| **Entropy**: Clasius inequality; statement, proof, application to a reversible cycle. Q/T as independent of the path. Entropy; definition, a property, principle of increase of entropy, entropy as a quantitative test for irreversibility, calculation of entropy using Tds relations, entropy as a coordinate. Introduction to available and unavailable energy.<br>**Air Standard and Gas power cycles**: Carnot cycle, Air standard Otto, Diesel, and Dual cycles, efficiency derivation. Ideal Brayton cycle, effect of reheat, regeneration and Intercooling- (Simple numerical problems on Otto, Diesel, Dual and ideal Brayton cycle only.).<br>**Experiential Learning**: Heat engines of all types form a very important and commercially used application based on thermodynamic principles.<br>**Video link / Additional online information**:<br>1. http://www.youtube.com/watch<br>2. https://youtu.be/LDXLOCTeJQE,<br>3. https://youtu.be/b5SPb6NHna4,<br>4. https://youtu.be/PB7n8Y74890<br>5. https://youtu.be/4-BI22Wx4Pc, | 8 Hrs |
| UNIT-V | |
| **Internal Combustion Engines**: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, heat balance, Morse test, Willian's line method, (Numerical problems on Heat balance sheet and Morse test only).<br>**Refrigeration**: Vapour compression refrigeration system, description, Refrigerating effect, capacity, Power required, Units of refrigeration, COP, Refrigerants and their desirable properties, Vapour absorption refrigeration system.<br>**Experiential learning**: Performance parameters, Morse test and heat balance analysis can be found by conducting the experiments in Energy conversion laboratory<br>**Video link / Additional online information**:<br>1 https://youtu.be/2iYqZ8tIP1I<br>2 https://youtu.be/BofCLgFqlSg<br>3 https://youtu.be/ICgjx-WX6UM<br>4 https://youtu.be/cobFAMZDS0o<br>5 https://youtu.be/oclgDmwEfZY | 8 Hrs |

Course Outcomes: After completing the course, the students will be able to

| | |
|---|---|
| CO1 | Define the basic concepts of thermodynamics like systems, equilibrium, process etc. Identify different work n heat interactions |
| CO2 | Understand First Law of Thermodynamics and its applications |
| CO3 | Understand Second Law of Thermodynamics and its applications |
| CO4 | Understand the concept of Entropy, Available and unavailable Energy. |
| CO5 | Describe the performance parameters of I.C. Engines and Refrigeration comparison of the parameters to improve the efficiency of the same. |

| Reference Books | |
|---|---|
| 1. | B K Venkanna & Swati B V, **Basic & Applied Thermodynamics,** PHI Learning, 2011 |
| 2. | P K Nag, **Engineering Thermodynamics**, Tata McGraw-Hill Education, 2005 |
| 3. | R K Rajput, **"Engineering Thermodynamics",** Laxmi Publications Pvt. Ltd., Sixth Edition, 2023 |
| 4. | **Yunus A Cengel; Michael A Boles,** Thermodynamics: An Engineering Approach (SIE) Paperback – 1 July 2017, McGraw Hill Education, ISBN-13: 978-9339221652 |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO2 | 3 | 3 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Semester: III | | |
|---|---|---|
| Material Science and Engineering (Theory and Practice) | | |
| Course Code: MVJ22ME33 | | CIE Marks: 50+50 |
| Credits: L:T:P: 3:0:2 | | SEE Marks: 50+50 |
| Hours: 40 L+26 P | | SEE Duration: 03+03 Hours |
| Course Learning Objectives: The students will be able to | | |
| 1 | Provide basic background for selection of materials for a wide range of products in engineering applications. | |
| 2 | Introduce the concept of crystal structure, atomic planes and directions and identify imperfections in solids. | |
| 3 | Elucidate phase stabilities and phase diagrams and identify the mechanism of phase transformations. | |
| 4 | Enumerate different metals and alloys and elucidate various heat treatment and power metallurgy techniques. | |

| | |
|---|---|
| 5 | Elucidate the corrosion and failure mechanisms in metals and alloys and introduce composite materials. |

| UNIT-I | |
|---|---|
| **Introduction:** Basics of Engineering Materials, their Classifications and Application, Basics of Advance Engineering Materials, Engineering requirements of materials, Properties of engineering materials, Criteria for selection of materials for engineering Applications.<br>**Crystal Structure:** Crystal Lattice, Unit Cell, Planes and directions in a lattice, Planar Atomic Density, packing of atoms and packing fraction, Classification and Coordination of voids, Bragg's Law. Imperfections in Solids: Types of imperfections, Point defects: vacancies, interstitials, line defects, 2-D and 3D-defects, Diffusion-Fick's laws, role of imperfections in diffusion. | 8 Hrs |
| **UNIT-II** | |
| **Solidification and Theory of Alloys:** Solidification of metals and an alloy, Nucleation and Growth during freezing of pure metal and alloy ingot/a casting Resultant macrostructures; Effects of Structure on Mechanical Properties.<br>**Phase and Phase equilibrium:** Unary and Binary equilibrium phase diagrams, Hume- Rothery Rules, Gibbs Phase Rule, Lever Rule, Fe-C equilibrium diagram, Different reactions like eutectic, eutectoid, peritectic and peritectoid; non-equilibrium cooling. | 8 Hrs |
| **UNIT-III** | |
| **Heat treatment:** Annealing, Normalizing, hardening, Tempering, Nitriding, Cyaniding, Induction Hardening and Flame Hardening, Recent advances in heat treat technology. TTT diagram, microstructural effects brought about by these processes and their influence on mechanical properties. | 8 Hrs |
| **UNIT-IV** | |
| **Corrosion and surface coating:** Introduction to corrosion, types of corrosion, mechanism of corrosion, corrosion prevention techniques coating materials, coating technologies, types of coating, advantages, and limitations.<br>**Failure of Materials:** Ductile and brittle failure mechanisms, Tresca, Von-mises, Maximum normal stress, Mohr-Coulomb and Modified Mohr-Coulomb theories, yield locus plots, fatigue failure, SN curve, endurance, and fatigue limits, modified goodman diagram, creep failure, fracture mechanics, Griffith criterion. | 8 Hrs |
| **UNIT-V** | |
| **Metals and Alloys:** Carbon and alloy steels-stainless steel and tool steel, maraging steel, cast iron-grey, white, malleable and spheroidal cast iron; Copper and Copper alloys-Brass, Bronze and Cupro-Nickel alloys; | 8 Hrs |

| | |
|---|---|
| Aluminum Alloys, Magnesium Alloys, Nickel based super alloys and Titanium alloys.<br>**Composite Materials**: Introduction, Classification, Metal Matrix Composites, Ceramic Matrix Composites, Polymer Matrix Composites, Natural fiber reinforced composites, Advantages, Limitations, Properties and Applications. | |

LABORATORY EXPERIMENTS

1. To determine the hardness values of different metal specimens by Rockwell/Vickers hardness testing machine.
2. To determine the hardness values of different metal specimens by Brinell hardness testing machine.
3. To determine the tensile strength, modulus of elasticity, yield stress, % of elongation and % of reduction in area of the metal specimen and to observe the necking.
4. To carry out the compression test on universal testing machine and determine the change in length/area and compression strength for the give specimen.
5. Carryout the Bending test/Single Shear/Double Shear test on the given specimens and to plot the stress strain graphs.
6. Determining the impact strength of a given material using Charpy/IZOD tests.
7. Carryout the Torsion test on the given specimen and to tabulate the readings and find the torsion values.
8. Demonstration of pin on disc wear test.
9. Demonstration of any two Nondestructive tests.
10. Preparation of the specimen and microstructure observation for different metals and alloys.
11. Demonstration of Fatigue test for the given specimen.

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Understand the atomic arrangement in crystalline materials and describe the periodic arrangement of atoms in terms of unit cell parameters. |
| CO2 | Understand the importance of phase diagrams and the phase transformations. |
| CO3 | Know various heat treatment methods for controlling the microstructure. |
| CO4 | Correlate between metals, alloys, material properties with component design and identify various kinds of failure mechanisms. |
| CO5 | Understand the application of the different types of composite materials. |

| Reference Books | |
|---|---|
| 3. | W. D. Callister, "Materials Science and Engineering-An Introduction", Wiley India, 6th Edition, 2006. |
| 4. | Kenneth G. Budinski and Michael K. Budinski, Engineering Materials, Prentice Hall India, 4th Edition, 2002. |
| 3. | V. Raghavan, "Material Science and Engineering", Prentice Hall India, 5th Edition, 2004. |

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|---|---|
| 4. | P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008. |

**Web links and Video Lectures (e-Resources):**

1. Bhattacharya. B, Materials Selection and Design, NPTEL Course Material, Department of Mechanical Engineering, Indian Institute of Technology Kanpur, http://nptel.ac.in/courses/112104122/

2. Prasad, R., Introduction to Materials Science and Engineering, NPTEL Course Material, Department of Materials 27 27 Science and Engineering, Indian Institute of Technology Delhi, http://nptel.ac.in/courses/113102080/

3. Subramaniam, A., Structure of Materials, NPTEL Course Material, Department of Material Science and Engineering, Indian Institute of Technology Kanpur, https://nptel.ac.in/courses/113104014/

4. Schuh, C., 3.40J Physical Metallurgy. Fall 2009. Massachusetts Institute of Technology: MIT Open Course Ware, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

5. Ghosh, R.N., Principles of Physical Metallurgy, IIT Kharagpur, http://nptel.ac.in/syllabus/113105024/

## Continuous Internal Evaluation (CIE):

### Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

### Laboratory- 50 Marks

The laboratory session is held every week as per the timetable and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

## Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students must answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three subdivisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | | | | | | | | | | | 2 |
| CO2 | 3 | 2 | 2 | 2 | | | 1 | | 2 | 1 | 2 | |
| CO3 | 3 | | | | | | | | 2 | | 2 | |
| CO4 | 3 | 2 | 2 | | | 2 | | | 2 | | | 2 |
| CO5 | 2 | | | | | | | | | | 2 | |

| Semester: III | | |
|---|---|---|
| Mechanics of Materials<br>(Theory) | | |
| Course Code: MVJ22ME34 | | CIE Marks:50 |
| Credits: L:T:P:S: 2:2:0:0 | | SEE Marks: 50 |
| Hours: 20L+20T | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | To study the distribution of various stresses in mechanical elements that deform under various loads. | |
| 2 | To know behaviour & properties of engineering materials. | |
| 3 | To understand the concepts of Principal stress and strains. | |
| 4 | To understand the concepts of calculation of shear force and bending moment for beams with different supports. | |
| 5 | To expose the students to concepts of Buckling of columns and strain energy. | |

| UNIT-I | |
|---|---|
| **Stresses and Strains:**<br>Introduction, Properties of materials, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Calculation of stresses in straight, Stepped and tapered sections, Composite sections, Stresses due to temperature change, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.<br>**Experiential Learning:** Load and Deformation Measurement Experiments in UTM<br>**Applications:** Stresses and strains induced in various applications like, chair/bench where the students are sitting, strain in the shoe while jogging, stress and strain induced in the concrete building etc.<br>**Video link:**<br>https://www.mtu.edu/materials/k12/experiments/tensile/. | 8 Hrs |

| UNIT-II | |
|---|---|
| **Analysis of Stress and Strain:**<br>Introduction to three dimensional state of stress, Stresses on inclined planes, Principal stresses and maximum shear stress, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions.<br>**Cylinders:**<br>Thin cylinder: Hoop's stress, maximum shear stress, circumferential and longitudinal strains, Thick cylinders: Lames equations.<br>**Experiential Learning:** Using strain gauges, students will measure the forces and subsequently calculate the stresses in metrology lab.<br>**Applications:**<br>Strain rosettes, Thick and Thin Cylinders<br>**Video link:**<br>https://www.youtube.com/watch?v=qHi8FPnWP6E | 8 Hrs |
| UNIT-III | |
| *Shear Force and Bending Moment:*<br>Type of beams, Loads and reactions, Relationship between loads, shear forces and bending moments, Shear force and bending moments of cantilever beams, Pin support and roller supported beams subjected to concentrated loads, uniformly distributed constant / varying loads.<br>*Stress in Beams:*<br>Bending and shear stress distribution in rectangular, I and T section beams.<br>**Experiential Learning:** Hand calculation of Shear force and bending moment distribution for bridges and buildings.<br>**Applications:** Shear Force and Bending Moment Distribution of beam members of buildings and structures.<br>**Videolink:**<br>https://www.youtube.com/watch?v=wbkvJmUEKHY | 8 Hrs |
| UNIT-IV | |
| *Theories of Failure:*<br>Maximum Principal stress theory, Maximum shear stress theory.<br>*Torsion:*<br>Circular solid and hallow shafts, Torsional moment of resistance, Power transmission of straight and stepped shafts, Twist in shaft sections, Thin tubular sections, Thin walled sections.<br>**Experiential Learning:** Torsion Experiment in Material Testing Lab<br>**Applications:** A propeller shaft of an automobile which transmits power and motion from engine to the wheels.<br>**Video link:** https://www.youtube.com/watch?v=-9DYHrqq51E | 8 Hrs |
| UNIT-V | |
| *Columns:* | 8 Hrs |

| | |
|---|---|
| Buckling and stability, Critical load, Columns with pinned ends, Columns with other support conditions, Effective length of columns, Secant formula for columns.<br>*Strain Energy:*<br>Strain energy due to axial, shear, bending, torsion and impact load. Castigliano's theorem I and II and their applications.<br>**Experiential Learning**: Impact test in Material Testing Lab and calculating the strain energy absorbed due to impact loading<br>**Applications**: Buckling and stability estimation in Metro, flyover and building columns<br>**Video link**:<br>https://www.youtube.com/watch?v=cZwg6XYpzRw | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Apply mathematical knowledge to Calculate the deformation behavior of simple structures. |
| CO2 | Critically analyze problem and solve the problems related to mechanical elements and analyze the deformation behavior for different types of loads. |
| CO3 | Analyze the deflection in beams. |
| CO4 | Analyze buckling and bending phenomenon in columns, struts and beams. |
| CO5 | Analysis of shaft for various cross sections. |

| Reference Books | |
|---|---|
| 1. | Bedi D S, "*Strength of Materials*", S Chand and Co. Ltd., New Delhi, 2019. |
| 2. | Ramamrutham S and Narayan R, "*Strength of Materials*", Dhanpat Rai and Sons, New Delhi, 1997. |
| 3. | Popov E P, "*Mechanics of Materials*", Prentice Hall Inc., Englewood Cliffs, New Jersey, 2015. |
| 4. | S S Bhavikatti Strength of Materials Paperback – 1 Vikas Publishing House Pvt Ltd. ISBN: 9788125927914, 9788125927914 |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 2 | 2 | 2 | - | - | - | 2 | 1 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | - | 2 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 1 | - | - | 2 | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | - | 2 | 2 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 3 | 2 | 3 | 3 |

| Semester: III | | |
|---|---|---|
| Computer Aided Machine Drawing<br>(Practical) | | |
| Course Code: MVJ22MEL35 | | CIE Marks:50 |
| Credits: 1 | | SEE Marks: 50 |
| Hours: 26 L: T : P :: 0 : 0 : 2 | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | To acquire the knowledge of CAD software and its features. Make the students to understand of the devices, instruments. | |
| 2 | To inculcate understanding of the theory of projection and make drawings using orthographic projections and sectional views. | |
| 3 | To familiarize the students with Indian Standards on drawing practices. | |
| 4 | To impart knowledge of thread forms, fasteners, keys, joints, couplings and | |
| 5 | To acquire the knowledge of Assembly Drawings. | |

| UNIT-I | |
|---|---|
| **Limits, Fits and Tolerances:** Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Types of fits with symbols and applications, Geometrical tolerances on drawings, Standards followed in industry.<br>**Orthographic views:** Conversion of pictorial views into orthographic projections of simple machine parts with and without section. (Bureau of Indian Standards conventions are to be followed for the drawings), Hidden line conventions, Precedence of lines.<br><br>**Laboratory Sessions/ Experimental learning:**<br>Conversion ISO view to orthogonal view of different machine components to be done using available software tool in the lab.<br><br>**Applications**: All manufacturing Industry.<br><br>**Video link / Additional online information:**<br>1. https://www.youtube.com/watch?v=-_qz8_sbhwY<br>2. https://www.youtube.com/watch?v=zO8coRhrJM0 | 05 Hrs |
| **UNIT-II** | |
| *Thread forms:* Thread terminology, sectional views of threads. ISO Metric (Internal & External), BSW (Internal and External), square, Acme and Sellers thread, American Standard thread.<br>*Fasteners:* Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut.<br><br>Laboratory Sessions/ Experimental learning: | 05 Hrs |

| | |
|---|---|
| • 2D drawing of a different type of threads are practiced using available software tool in the lab and same threads are manufactured in M/C shop.<br>**Applications:** Assembly and sub assembly of components.<br>**Video link / Additional online information:**<br>1. https://www.youtube.com/watch?v=TPURJnlekeo<br>2. https://www.youtube.com/watch?v=Z38Aq9ykUCM | |
| **UNIT-III** | |
| *Riveted joints:* Single and double riveted lap joints, Butt joints with single/double cover straps<br>(Chain and zigzag using snap head riveters).<br><br>**Laboratory Sessions/ Experimental learning:**<br>• Lap and Butt joint of different plate thickness are drawn using soft wear.<br>**Applications:** Bridge construction, Boiler construction, Automobile sheet metal assembly. **Video link / Additional online information:**<br>https://www.youtube.com/watch?v=C5ZPaCvoigw | 05 Hrs |
| **UNIT-IV** | |
| *Joints:* Cotter joint (socket and spigot), Knuckle joint (pin joint) for two rods.<br><br>**Laboratory Sessions/ Experimental learning:**<br>• 2D Drawing are drawn using software & 3D individual parts are made and assembled as per given drawing.<br>**Applications:** Power transmission assembly, Automobile (Heavy Trucks) industry.<br>**Video link / Additional online information:**<br>1. https://www.youtube.com/watch?v=J9Aj17MAyLY<br>2. https://www.youtube.com/watch?v=esfr74WhbYg<br>3. https://www.youtube.com/watch?v=qjGF08LvZ9M | 05 Hrs |
| **UNIT-V** | |
| *Assembly Drawings: (Part drawings shall be given)* | 06 Hrs |

| | |
|---|---|
| 1. Plummer block (Pedestal Bearing)<br>2. I.C. Engine connecting rod<br>3. Screw jack (Bottle type)<br>4. Tailstock of lathe<br>5. Machine vice<br>6. Lathe square tool post<br><br>Laboratory Sessions/ Experimental learning:<br><br>☒ 3D individual parts are made and assembled as per given drawing.<br><br>Applications: Heavy equipment manufacturing, IC engine manufacturing, Automotive industry.<br><br>Video link / Additional online information:<br><br>https://www.youtube.com/watch?v=4hhJ0OSKVYg&list=PLQL-DlNb9_TXAbUK_H4JyZnhv9MW3nhG<br><br>https://www.youtube.com/watch?v=boyN1l3fA6g&list=PLQL-DlNb9_TVqG1Zrw-9F-SOIItg3T5fD<br><br>https://www.youtube.com/watch?v=-9AKKLoUICw&list=PLQL-DlNb9_TXW68eA3yVkXQXWDUaYcwOX<br><br>https://www.youtube.com/watch?v=yKl_FiUdAu4&list=PLQL-DlNb9_TUHs8CUXYw-Lna-Gp4rTu9g<br><br>https://www.youtube.com/watch?v=pyzsBiU-raE&list=PLQL-DlNb9_TXofDUwlRjLzPst-sRbG3 | |

| Course outcomes: | |
|---|---|
| CO1 | Students will be able to convert Orthographic views of machine parts with and without sectioning in 2D. |
| CO2 | Able to understand design of thread forms and Sectional views for threads in 2D. |
| CO3 | Students able to Draw the Hexagonal and square headed bolt and nut with washer, screw assemblies in 2D. |
| CO4 | Students will be able to draw the single and double riveted joints, in 2D. |
| CO5 | Students will be able to construct assemblies of mechanical component in 3D environment |

| Reference Books: | |
|---|---|
| 1. | N.D.Bhat & V.M.Panchal, "*Machine Drawing*", Published by Charotar Publishing House, 1999. |
| 2. | N.Siddeshwar, P.Kannaih, V.V.S. Sastri, "*Machine Drawing*" published by Tata Mc.Grawhill, 2006. |
| 3. | S. Trymbakaa Murthy, "*A Text Book of Computer Aided Machine Drawing*" CBS Publishers, New Delhi, 2007. |
| 4 | K.R. Gopala Krishna, "*Machine Drawing*" Subhash publication. |

| CO-PO | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 1 | 1 | 2 | - | - | - | - | 3 | 1 | 3 |
| CO2 | 3 | 3 | 1 | 1 | 2 | - | - | - | - | 1 | 1 | 1 |
| CO3 | 3 | 3 | 1 | 1 | 2 | - | - | - | - | 1 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 1 | 2 | - | - | - | - | 1 | 2 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 2 | - | - | - | - | 1 | 3 | 3 |

High-3, Medium-2, Low-1

| |
|---|
| **Scheme of Examination:** As per the MVJCE Autonomous Regulations, Semester End Examination (SEE) is to be conducted and evaluated for 100 marks which will be proportionately reduced and considered for 50 marks by the Grading authority. |
| **Module 1 (Q1) or Module 2 (Q2)**: 12.5 Marks Weightage |
| **Module 3 (Q3) or Module 4 (Q4)**: 12.5 Marks Weightage |
| **Module 5 (Q5) or Module 5 (Q6)**: 25 Marks Weightage |

| Semester: III | | |
|---|---|---|
| Electric and Hybrid Vehicles Technology (Theory) | | |
| Course Code: MVJ22ME361 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40L | | SEE Duration: 3 Hrs |

| Course Learning Objectives: The students will be able to | |
|---|---|
| 1 | To be able to learn and understand basic concepts of electric Vehicles |
| 2 | To be able to learn and understand basic concepts of hybrid electric Vehicles |
| 3 | To be able to understand the concepts of Propulsion unit of vehicles |
| 4 | To be able to understand varieties of batteries in automotive vehicles |
| 5 | To be able to understand energy storage requirements |

| UNIT-I | |
|---|---|
| Introduction to Electric Vehicle: History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions. | 8 Hrs |
| UNIT-II | |
| Induction to Hybrid Electric Vehicle: Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. | 8 Hrs |
| UNIT-III | |
| Propulsion unit: Introduction to transmission components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency. | 8 Hrs |
| UNIT-IV | |
| Fuel Cells and Batteries: Fuel Cell based energy storage and its analysis, Battery based energy storage devices and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, selecting the energy storage technology, Calculation for the ratings. | 8 Hrs |
| UNIT-V | |
| Energy Storage Requirements in Hybrid and Electric Vehicles, Hybridization of different energy storage devices, Sizing the drive system, Energy Management Strategies, Implementation issues of energy | 8 Hrs |

| | |
|---|---|
| management strategies, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV). | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Elucidate the evolution of Hybrid and Electric Vehicles and their technology. |
| CO2 | Compare the different types of drive trains and transmission systems involved in Electric and Hybrid Vehicles. |
| CO3 | Elucidate the use of different energy storage devices for electric and hybrid vehicles. |
| CO4 | Summarize the aspects of energy storage requirements in hybrid and electric vehicles. |
| CO5 | Identify the different implementation issues of energy management strategies from case studies on design of battery and hybrid electric vehicles. . |

| Reference Books | |
|---|---|
| 1. | Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003. |
| 2. | A. K. Babu, Electric and Hybrid Vehicles, Second Edition, 1 January 2022 (Author) Khanna Publishing (1 January 2022); Khanna Book Publishing Company, ISBN-13 : 978-8195123155 |
| 3. | Seth Leitman, "Build Your Own Electric Vehicle" MC Graw Hill, 1st Edition, 2013. |
| 4. | Electrical Vehicle Technology: The Future Towards Eco-Friendly Technology... Paperback by Prof. Sunil R. Pawar, Publisher : Notion Press; 1st edition (11 September 2021), ISBN-10 : 1685545610 |
| Web links and Video Lectures (e-Resources):<br>NOC:Fundamentals of Electric vehicles: Technology & Economics, IIT Madras<br>Prof. Ashok Jhunjhunwala Prof. Prabhjot Kaur Prof. Kaushal Kumar Jha Prof. L Kannan<br>https://nptel.ac.in/courses/108106170 | |

Continuous Internal Evaluation (CIE):
Theory for 50 Marks
CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.
Semester End Examination (SEE):
Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | - | - | 3 | - | 1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | - | 1 | - | - | - | 3 | 1 |
| CO3 | 3 | 2 | 1 | - | 2 | - | - | - | - | - | - | 1 |
| CO4 | 3 | 2 | 1 | 3 | 3 | - | 2 | - | - | - | - | 1 |
| CO5 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | - | - | - | - | 1 |

| Semester: III | | |
|---|---|---|
| INTERNET OF THINGS (IOT) FOR SMART FACTORIES<br>(Theory) | | |
| Course Code: MVJ22ME362 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40L | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | To introduce different architectures used for connected smart devices. | |
| 2 | To study various protocols used in the Internet of Things environment. | |
| 3 | To Design and Develop Internet of Things based solution for real world problems. | |

| | |
|---|---|
| 4 | To present a problem oriented in depth knowledge of IOT & Smart Manufacturing Factories. |
| 5 | To address the underlying concepts and methods behind IOT & Smart Manufacturing Factories. |

| UNIT-I | |
|---|---|
| **The Internet of Things**: An overview, Design Principles for Connected Devices, Internet Principles. Thinking about Prototyping – Costs versus ease of prototyping, prototyping and Production, open source versus Closed Source.<br>**Prototyping Embedded Devices**: Electronics, Embedded Computing Basics, Arduino, Raspberry Pi, Beagle Bone Black, etc., Electric Imp and other notable platforms Prototyping of Physical Design. Prototyping online Components – Getting Started with an API, Writing a New API.<br>**Real Time Reactions**: Other Protocols, Techniques for Writing Embedded Code – Memory Management, Performance and Battery Life, Libraries and debugging.<br>**Experiential Learning**: Sketch the architecture of IoT Toolkit and explain each entity in brief and Sensors, Gateway and Cloud interface.<br>**Video Links/Any other special information**:<br>1. https://www.youtube.com/watch?v=WUYAjxnwjU4&list=PLJ5C_6qdAvBG7SHg5mLOQq6bzF-sOPu3k<br>2. https://www.youtube.com/watch?v=hdZzNOQV5vU<br>3. https://www.tutorialspoint.com/internet_of_things/internet_of_things_overview.htm<br>4. https://www.youtube.com/watch?v=2v6M5DOzTfc&list=PLdguAlzSoZpqd2nYaFMeSrjQRG7_5Yd3K | 08 Hrs |
| **UNIT-II** | |
| **Automatic Storage Management in a Cloud World**: Introduction to Cloud, Relational Databases in the Cloud, Automatic Storage Management in the Cloud.<br>Smart Connected System Design Case Study.<br>**Internet of Things Privacy, Security and Governance**: Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smarties Approach. Data Aggregation for the IoT in Smart Cities, Security.<br>**Experiential Learning**: Configuring cloud database management and accessing and Data analysis from cloud and reporting.<br>**Video Links/Any other special information**:<br>1. https://www.youtube.com/watch?v=hHvMan9HWYI<br>2. https://www.youtube.com/watch?v=g-JuCEvkq9I<br>3. https://www.scribd.com/document/339463370/Unit-3-IoT-Privacy-Security-Governance | 08 Hrs |

| | |
|---|---|
| 4. https://www.youtube.com/watch?v=foJ8rh-3T_Y | |
| UNIT-III | |
| **Introduction to Smart Manufacturing**: What is "smart manufacturing" really and how does it differ from conventional/legacy Manufacturing- Smart Manufacturing Processes – Three Dimensions: (1) Demand Driven and Integrated Supply Chains, (2) Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations), (3) Real Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization and reduction of GHG).<br>**Experiential Learning**: Introduction to Smart Manufacturing, distinguish its signification in comparison to conventional manufacturing.<br>**Video Links/Any other special information**:<br>1. https://www.youtube.com/watch?v=sdgI072DJNM<br>2. https://www.youtube.com/watch?v=h9t06cyC7Es<br>3. https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/inspired/smart-manufacturing | 08 Hrs |
| UNIT-IV | |
| **Smart Design/Fabrication**: Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices.<br>**Experiential Learning**: To Study about tools for Smart Manufacturing.<br>**Video Links/Any other special information**:<br>6. https://www.youtube.com/watch?v=WCfwEYaPuDQ<br>7. https://www.youtube.com/watch?v=y8CJPBty9mI<br>8. https://www.youtube.com/watch?v=IMPbKVb8y8s | 08 Hrs |
| UNIT-V | |
| **Smart Applications**: Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes, Smart Energy Management of manufacturing processes and facilities.<br>**Smart and Empowered Workers**: Eliminating Errors and Omissions, Deskilling Operations, Improving Speed/Agility, Improving Information Capture/Traceability, Improving Intelligent, Decision Making under uncertainty Assisted/Augmented Production, Assisted/Augmented, Assembly, Assisted/Augmented Quality, Assisted/Augmented Maintenance, Assisted/Augmented, Warehouse Operations and Assisted Training.<br>**Experiential Learning**: To study about Smart Application and to study about Smart and Empowered working.<br>**Video Links/Any other special information**:<br>9. https://www.youtube.com/watch?v=N_z4OaSuoAA<br>10. https://www.youtube.com/watch?v=Bv7PXrvpLNs | 08 Hrs |

| | |
|---|---|
| 11. https://www.youtube.com/watch?v=xn32a320sv4<br>12. https://www.youtube.com/watch?v=Qxe68ExM148 | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Able to understand the basic architecture of Internet of Things based Devices. |
| CO2 | Able to analyze light weight protocols implemented for connected devices. |
| CO3 | Able to develop firmware for controlling wireless devices and Able to design and develop Smart Devices using IoT. |
| CO4 | The student can identify different areas of IOT and Smart Manufacturing Factories. |
| CO5 | Can find the applications of all the areas in day to day life in Factories. |

| Reference Books | |
|---|---|
| 1. | A. McEwen and H. Cassimally, Designing the Internet of Things, 1st edition, Wiley, 2013, ISBN-10: 111843062X. |
| 2. | N. Vengurlekar and P. Bagal, Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management, 1st edition, McGraw-Hill Education, 2013, ISBN-10: 0071790152. |
| 3. | M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, 1st edition, Morgan Kaufmann, 2010, ISBN-10: 0123748992. |
| 4. | Raj Kamal, "Internet of Things: Architecture and Design Principles", First Edition, McGraw Hill Education, 2017. |

Continuous Internal Evaluation (CIE): Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE): Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping |
|---|

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Semester: III | | |
|---|---|---|
| SMART MATERIALS AND SYSTEMS<br>(Theory-Professional Elective) | | |
| Course Code: MVJ22ME363 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40L | | SEE Duration: 3 Hrs |
| Course Learning Objectives: | | |
| 1 | To develop the student's ability to learn emerging materials and technologies. | |
| 2 | To make students to learn prefabricated building components | |
| 3 | To make students learn the concepts of piezoelectricity and smart composites for real time applications. | |
| 4 | To be able to appreciate the principles of shape memory alloys and magneto and electrorheological fluids. | |
| 5 | To be able to implement the concepts of 3D printing in building prototypes and models. | |

| UNIT-I | |
|---|---|
| **Introduction to Smart Materials:** Smart Materials – Definition, Types , Emerging Materials, Honey comb structure (Carbon composites), Nano-materials, engineered polymers, emerging sustainable by products (Fly ash and GGBS) and construction chemicals.<br>**Experiential Learning**: Synthesis of Honeycomb structure and composites<br>**Video Links/Any other special information:**<br>1. https://www.youtube.com/watch?v=yXHlIowQntk | 8 h |

| | |
|---|---|
| 2. https://nptel.ac.in/courses/112104173 | |
| UNIT-II | |
| **Prefabricated/ Manufactured building components**<br>Definition, types of prefabricated/ manufactured building components and infrastructure, modular coordination, standardization, materials, systems, production, transportation and installation. Wood, Engineered Wood and Bamboo as construction materials.<br>**Experiential Learning:** Fabrication of prefabricated concrete slabs<br>**Video link / Additional online information:**<br>5. https://www.youtube.com/watch?v=FdbHC4sfqBo<br>6. https://archive.nptel.ac.in/courses/124/105/124105013/ | 8 h |
| UNIT-III | |
| **Piezo-electric materials and Smart Composites:** Definition, Principles of Piezo-electricity, materials (Polymers and Ceramics), sensors (Piezo-electric sensor, strain gauge, shear sensor, in-plane and out of plane sensor, accelerometer), smart composites<br>**Experiential Learning:** Demonstration of the concept of piezoelectricity through simple models and prototypes<br>**Video Links/Any other special information:**<br>4. https://www.youtube.com/watch?v=_XABS0dR15o<br>5. https://nptel.ac.in/courses/112104173<br>6. https://www.youtube.com/watch?v=N1ALRmT4s9I<br>7. https://www.youtube.com/watch?v=3oVf0r51Fzw | 8 h |
| UNIT-IV | |
| **Shape Memory Alloys:**<br>Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, NiTiNOL actuators.<br>**Electro rheological and Magneto rheological Fluids:**<br>Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others).<br>**Experiential Learning:** Demonstration of Shape Memory Effect.<br>**Video link / Additional online information:**<br>13. https://www.youtube.com/watch?v=Pn-6bGORy0U<br>14. https://www.sciencedirect.com/topics/materials-science/shape-memory-effect | 8 h |
| UNIT-V | |
| 3-D Printing<br>Importance, Historic development, advantages, common terminologies, classification, Process chain, 3–D modelling, Data conversion and transmission, checking and preparation, Building, Post processing, Applications<br>**Video link / Additional online information:** | 8 h |

| | |
|---|---|
| 1. https://www.youtube.com/watch?v=m12bX1eEVDM<br>2. https://archive.nptel.ac.in/courses/112/103/112103306/ | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Make use of the emerging materials for construction |
| CO2 | Decide the proper prefabricated building component in construction of smart structures |
| CO3 | Use smart materials and methods in building construction |
| CO4 | Apply the concepts of Shape memory alloys and ER and MR fluids in real time. |
| CO5 | Prepare 3-D models and prototypes from 3D printing process |

| Reference Books | |
|---|---|
| 1. | Donald R. Askeland and Pradeep P. Fulay, Essentials of Materials Science and Engineering, 2009, Cengage Laerning. |
| 2. | "Smart Structures–Analysis and Design", A.V.Srinivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267). |
| 3. | "Smart Materials and Structures", M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107) |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of CO's and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 2 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO2 | 2 | 3 | 2 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| Instrumentation and Controls | | |
| Course Code: MVJ22ME364 | | CIE Marks:50 |
| Credits: L:T:P: 3:0:0 | | SEE Marks: 50 |
| Hours:40 L | | SEE Duration: 03 hours |
| Course Learning Objectives: The students will be able to | | |
| 1 | To provide a basic knowledge about measurement systems and their components | |
| 2 | To learn about various sensors used for measurement of mechanical quantities. | |
| 3 | To learn about system stability and control and integrate the measurement systems with the process for process monitoring and Control. | |
| 4 | To develop competence in sensors, transducers and terminating devises with associated parameters and illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments. | |
| 5 | Illustrate the use of various plots for stability analysis. | |

| UNIT-I | |
|---|---|
| **Basic Concepts of Measurement and Metrology**: Definition and significance of measurement, Generalized measurement system, Performance characteristics of measuring instruments, Inaccuracy of Measurements, Definition and objectives of metrology, Introduction to standards, Types of standards, slip gauges.<br>**System of Limits, Fits, Tolerances and Gauging**: Definition of tolerance, specification in assembly, Principle of inter-changeability and selective assembly. Concept of limits of size and tolerances, Compound tolerances, accumulation of tolerances. Definition of fits, types of fits. Hole basis system and shaft basis system, Geometric dimensioning and tolerance.<br>**Laboratory Sessions/ Experimental learning**:<br>• Building dimensions using slip gauges and angle gauges.<br>**Applications**: Measurement and manufacturing of other processes, defect detection, Calibration and quality Control.<br>**Video link / Additional online information** :<br>https://lake.videoken.com/nptel/search/Metrology%20/video/BqAmlOl8uzs?tocitem=4 | 8 Hrs |
| UNIT-II | |
| **Comparators**: Characteristics and classification of comparators. Mechanical comparators-Johnson Mikrokator, Sigma Comparators, Optical Comparators - principles, Zeiss ultra-optimeter, Electric and Electronic Comparators, LVDT, Pneumatic Comparators, Solex Comparator, Back Pressure gauges. | 8 Hrs |

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|---|---|
| **Screw thread and Gear measurements, Surface Roughness measurements.**<br>**Sensors and Transducers**: Introduction, Transfer efficiency, Loading effect, Primary and Secondary transducers, classification of Sensors and transducers with examples. Advantages and limitations of each type of sensors and transducers.<br>**Signal Conditioning**: Mechanical systems, Electrical intermediate modifying devices, Input circuitry simple current sensitive circuit, Electronic amplifiers, Filters, Types of filters, telemetry, Cathode ray oscilloscope, Oscillographs.<br>**Applications**: Compare voltages and currents to measure minute and micro displacements.<br>**Video link / Additional online information** :<br>https://lake.videoken.com/nptel/search/Comparators%20 | |
| UNIT-III | |
| **Strain and Force Measurement**: Methods of strain measurement, Strain gauges, Preparation and mounting of strain gauges, Gauge factor, Proving ring.<br>**Measurement of Torque**: Introduction, Prony or Brake Dynamometer, Hydraulic dynamometer.<br>**Measurement of Pressure**: Introduction, Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani Gauge.<br>**Temperature Measurement**: Resistance thermometers, Wheatstone bridge circuit, Thermocouple, Laws of thermocouple, Thermocouple materials. Pyrometers, Optical pyrometers.<br>**Introduction to Coordinate Measuring Machine**.<br>**Laboratory Sessions/ Experimental learning**:<br>Study of strain gauge and application. Study of thermistors, resistance thermometers and its operation. Study of pyrometer, thermocouple and its use.<br>**Applications**: measurement of strain in load bearing structures along load paths, temperature/pressure gradient in high pressure vessels.<br>**Video link / Additional online information**:<br>https://lake.videoken.com/nptel/search/Strain%20gauge/ | 8 Hrs |
| UNIT-IV | |
| **Introduction**: Components of a control system, Open loop and closed loop systems, Types of controllers, Mathematical Models of Mechanical systems<br>**Time domain performance of control systems**: Typical test signal, Unit step response and time domain specifications of first order, second order system. Steady state error, error constants.<br>**Block diagram algebra,** Reduction of block diagram, Signal flow graphs, Gain formula for signal flow graphs, State diagram from differential equations.<br>**Laboratory Sessions/ Experimental learning**:<br>Study of On-Off Controller for Flow/ Temperature.<br>**Applications**: Automation and control of Electronic circuits, wireless communication and broadcasting.<br>**Video link / Additional online information** :<br>https://archive.nptel.ac.in/courses/108/106/108106098/ | 8 Hrs |
| UNIT-V | |
| **Stability of linear control systems**: Routh's criterion, Root locus, Determination of phase margin and gain margin using root locus.<br>Stability analysis using Polar plot, Nyquist plot, Bode plot, Determination of phase margin and gain margin using Bode plot. | 8 Hrs |

| | |
|---|---|
| **Laboratory Sessions/ Experimental learning**: Study of Control Modes like P, PD, PI, PID for Pressure / Temperature / Flow.<br>**Video link / Additional online information** :<br>https://archive.nptel.ac.in/courses/108/106/108106098/ | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Understand the objectives of metrology, methods of measurements, selection of measuring instruments, standards of measurement and calibration of end bars. |
| CO2 | Describe the slip gauges, wringing of slip gauges and building of slip gauges, angle measurement using sine bar, sine center, angle gauges, optical instruments and straightness measurement using Autocollimator. |
| CO3 | Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design. |
| CO4 | Understand the principle of comparators, dial indicator, LVDT, pressure gauges, comparator and measuring devices. |
| CO5 | Understand the concepts of stability of control systems. |

| Reference Books : Title, Author, Edition, year of publication, publisher, ISBN | |
|---|---|
| 1. | E.O. Doebelin, "Measurement Systems (Applications and Design)", 5th ed.- - McGrawHill. 2004, 9780072438864, 007243886X. |
| 2. | Beckwith Marangoni and Lienhard, "Mechanical Measurements" Pearson Education, 6th Ed., 2006. ISBN-13 - 978-0201847659 |
| 3. | Control Systems Engineering S Palani Tata McGraw Hill Publishing Co Ltd ISBN-13 9780070671935 |
| 4. | Control Systems Engineering IjNagrath, M Gopal New Age International (P) Ltd 2018 |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of

three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO2 | 3 | 3 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| MANUFACTURING PROCESS<br>(Theory) | | |
| Course Code: | MVJ22ME41 | CIE Marks:50 |
| Credits: | L:T:P:S: 3:0:0 | SEE Marks: 50 |
| Hours: | 40L | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | Recognize the various manufacturing principles and techniques. To gain | |

| | |
|---|---|
| | theoretical and practical knowledge in material casting processes and develop an understanding of the dependent and independent variables which control materials casting in a production setting. |
| 2 | Describe moulding, patterns and moulding furnaces. Determine the appropriate parameters for different manufacturing processes. Justify the most appropriate manufacturing process for a given product. |
| 3 | Enable the students to acquire a fundamental knowledge on metal forming technology which is necessary for an understanding of industrial processes and to introduce students to the wide range of materials and processes in plastic region, which are currently used in manufacturing industry. |
| 4 | Provide methods of analysis allowing a mathematical/physical description of polymer processing and powder metallurgy techniques in manufacturing. |
| 5 | Enable the students to identify the processes characteristics, select the main operator parameters, the tool geometry and materials, and determine forces and power required to select the main and auxiliary equipment for all non-conventional machining. |

| UNIT-I | |
|---|---|
| *Manufacturing Process*: Introduction to basic manufacturing, Classification of manufacturing process, Primary manufacturing process of Iron and Aluminium, Primary and Secondary Manufacturing process classification and Applications. Introduction about metal casting.<br>*Pattern Making:* Functions of pattern, Classification of pattern, Different pattern materials, various pattern allowances in design of pattern, Simple problems in design of pattern.<br>*Mould Making:* Moulding sand ingredients, Types of Moulds, Mould making, Desirable properties of Sand Mould, functions of cores. Concept of gating system, different types of gating systems, gating system design, risering design.<br>*Casting* – Types of Casting, Advantages, Limitations, and Applications, Casting defects.<br>Laboratory Sessions/ Experimental learning: | 8 Hrs |

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|---|---|
| • Demonstration of casting and moulding process (sand casting) in foundry laboratory.<br>Applications:<br>• Engineering and Developments Limited: Sand Casting Foundry UK, Casting Foundry UK, Sand Castings Manufacturer<br>https://youtu.be/1x3uJ-KSyjY<br>https://www.youtube.com/watch?v=1x3uJ-KSyjY<br>• Society of Manufacturing Engineers - https://www.sme.org/<br>o Shell Mould Casting Process : https://www.youtube.com/watch?v=28_I7Bdz4yY<br>o Die Casting Process : https://www.youtube.com/watch?v=0XkDK46rwvQ<br>o Aluminium Casting Process :<br>https://www.youtube.com/watch?v=UmVjLSDDHIY&list=PLUvI3up7Htf6kur1fu1yRI rdNBwqJQ4po&index=18<br>Video link / Additional online information:<br>• Sand Casting Process: https://www.youtube.com/watch?v=mx1cqeRUYwI<br>• Fundamentals of manufacturing processes, Mechanical Engineering, Dr. D. K. Dwivedi IIT Roorkee, Video Lecture.<br>https://nptel.ac.in/courses/112/107/112107219/<br>• Manufacturing Process Technology -Part I Mechanical Engineering, Dr. Shantanu Bhattacharya, IIT Kanpur, Video Lecture https://nptel.ac.in/courses/112/104/112104195/<br>• Sand Casting Animation by Force Beyond (https://www.forcebeyond.com) https://www.youtube.com/watch?v=fCyaJ8Q76U8 | |
| UNIT-II | |
| **Introduction to Welding:** Oxy-acetylene welding, types of flames, welding torches, welding techniques. Resistance welding-spot, seam, projection and butt welding. Laser beam welding, Electron beam welding. Friction welding, Friction stir welding and Ultra sonic welding. | 8 Hrs |

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|---|---|
| **Thermal and metallurgical consideration**: Temperature distribution, heating and cooling curves, HAZ and parent metal, micro and macro structures, solidification of weld and properties.<br>**Welding defects and Inspection**: Visual, Magnetic Particle, Fluoroscent particle, ultrasonic, Radiography, Eddy current, holography methods of inspection.<br>**Laboratory Sessions/ Experimental learning**:<br>• Studying about single point cutting tool and its geometry.<br>**Applications**: Heavy fabrication industry.<br>**Video link / Additional online information**:<br>https://www.youtube.com/watch?v=g7MkIBdl06c&list=PLwdnzlV3ogoUQnGO8eFFygVBTjF0xyYMq<br>https://www.youtube.com/watch?v=mmKy5PbndQI&list=PLyqSpQzTE6M-KwjFQByBvRx464XpCgOEC | |
| UNIT-III | |
| ***Metal Forming Processes***: Advantages of Mechanical Working Processes, Difference Between Hot and Cold Working, Advantages and Disadvantages of Cold and Hot Working Processes, Classification of Metal Forming Processes.<br>***Forging:*** Introduction, Classification of Forging, Die Forging with Power Hammers, Open Die Forging, Impression Die Forging, Closed Die Forging, Forging Defects.<br>***Rolling:*** Introduction, Nomenclature of Rolled Products, Mechanism of Rolling, and Types of Rolling Mill, Rolls and Roll Pass Design, Ring Rolling, Cold Rolling.<br>**Laboratory Sessions/ Experimental learning**:<br>• Demonstration of forging and rolling operations in Foundry laboratory.<br>**Applications**:<br>• MIT - Massachusetts Institute of Technology - http://web.mit.edu/2.810/www/files/lectures/2015lectures/lec6-sheet-metal-forming-2015.pdf<br>• Simufact Engineering —manufacturing simulation specialists — https://www.simufact.com/fields-of-application-forming.html | 8 Hrs |

| | |
|---|---|
| Video link/Additional online information:<br>• Principles of Metal Forming Technology, Mechanical Engineering. Dr. Pradeep K. Jha IIT Roorkee, Video Lecture.<br>https://nptel.ac.in/courses/112107112102507 | |
| UNIT-IV | |
| *Powder Metallurgy:* Introduction to powder metallurgy, Preparation of powders (Atomization, Electrolysis, and Granulation Process, Mechanical Alloying), Powder Blending, Powder Compaction, Sintering. Finishing operations, application of powder metallurgy products, advantages and limitations. *Plastic Products Manufacturing Process*: Injection moulding, Extrusion, and Blow moulding. Galvanizing Process and Electroplating Process.<br>*Brief discussion on following topics*: Micro Machining and Nano Machining Process, Super Plasticity, Solidification Mechanism and volume shrinkage.<br>Laboratory Sessions/ Experimental learning:<br>• Demonstration of welding process and sheet metal work in the Welding shop<br>• European Powder Metallurgy Association :<br>https://www.epma.com/powder-metallurgy-process<br>• Comtec Mfg., Inc —Powder Metallurgy Specialist<br>*https://www.youtube.com/watch?v=azGg68B-GlA*<br>Video link / Additional online information:<br>1. NPTEL : Powder Metallurgy Material :<br>https://nptel.ac.in/content/storage2/courses/112101005/downloads/Module_3_Lecture_6_final.pdf<br>2. ASME *:* Powder Metallurgy and its Applications<br>www.asminternational.org<br>https://www.asminternational.org/documents/10192/1849770/Z05438L_Sample.pdf/fee7b45-9176-4911-bc5d-bd8abc26e153<br>3. EPMA : Powder Metallurgy Component Production Cycle :https://youtu.be/_eM49JlmFp0 | 8 Hrs |
| UNIT-V | |
| *Extrusion, Wire Drawing, Tube Drawing and Making*: Introduction, | 8 Hrs |

Extrusion Processes, Machines for Extrusion, Extrusion Defects, Wire Drawing, Tube Drawing.

*Press Work and Die-Punch Assembly:* Tools, Bending, Deep Drawing, Coining and Embossing, Coining.

**Introduction to Sheet metal forming:** Mechanical, Hydraulic and pneumatic press machines, applications and limitations of Presses, Shearing, blanking, piercing, punching, nibbling, lancing, notching and non – shearing, bending, stretching, spinning, embossing, coining, drawing, operation & applications of stretch forming & deep drawing, defects in sheet metal formed components, simple numericals to estimate the force requirement in punching.

**High Energy Rate Forming:** operation & applications of explosive forming, Electro hydraulic forming & Electromagnetic forming.

*Laboratory Sessions/ Experimental learning:*

- Demonstration of tube bending, die and punch assembly and grinding operations in Machine Shop.

*Applications: Reliable EDM - Tool and Die Making*
https://www.youtube.com/watch?v=z3118Y4FeIU&list=PLC75FAAB1F1C22EED&index=3

*Video link / Additional online information:*

Society of Manufacturing Engineers (SME)

- Tool Materials:

https://www.youtube.com/watch?v=OuH9bIwTazE&list=PLB8F8FCFCB2E640DE

- Cutting Tool Design:

https://www.youtube.com/watch?v=GCQT4I99zX4&list=PLB8F8FCFCB2E640DE&index=2

- Fixture Design:

https://www.youtube.com/watch?v=SJ1nvHKIwLRU&list=PLB8F8FCFCB2E640DE&index=3

- Progressive Die Design:

https://www.youtube.com/watch?v=S9qzJat3Mzk&list=PLB8F8FCFCB2E640DE&index=4

| | |
|---|---|
| • Rapid Tooling Design:<br>https://www.youtube.com/watch?v=3VEUVl6G8&list=PLB8F8FCFCB2E640DE&index=6<br>• Trouble Shooting Tool and Die Design:<br>https://www.youtube.com/watch?v=JFo7eooXE2w&list=PLB8F8FCFCB2E640DE&index=8 | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Identify and explain all the steps involved in basic casting processes. |
| CO2 | Identify and explain the principle behind metal forming process and detail all the forging and rolling process. |
| CO3 | Categorise and explain all the special casting processes and Press and Die punch assembly |
| CO4 | Understand the process of Powder Metallurgy and Polymer product manufacturing process along with micro and Nano machining. |
| CO5 | Categorise and explain the non-conventional Machining Process and its applications. |

| Reference Books | |
|---|---|
| 1. | Degarmo, Black & Kohser, "*Materials and Processes in Manufacturing*" |
| 2. | P N Rao, "*Manufacturing Technology: Foundry, Forming and Welding*", 2nd Edition Tata Mc Graw-Hill Publication. |
| 3. | O.P Khanna, "*Foundry Technology*", Dhanpat rai publications-2003 reprint. |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 2 | 2 | 2 | - | - | - | 2 | 1 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | - | 2 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 1 | - | - | 2 | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | - | 2 | 2 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 3 | 2 | 3 | 3 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| MACHINING SCIENCE & OPERATION<br>(Theory+Practicals) | | |
| Course Code: MVJ22ME42 | | CIE Marks:50+50 |
| Credits: L:T:P:S: 3:0:2:0 | | SEE Marks: 50+50 |
| Hours: 40 L+26 P | | SEE Duration: 03+03 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | This course will highlight topics related to metal cutting. | |
| 2 | Appreciate the working of different types of turning machines. | |
| 3 | The course will deal with milling shaping and drilling of materials using single and multipoint cutting tool. | |
| 4 | Appreciate the Gear cutting methodology, finishing operation, and different non-traditional machining processes. | |

| UNIT-I | |
|---|---|
| **Theory of Metal Cutting**: Single point cutting tool nomenclature, Merchants circle diagram and simple problems. Tool wear, tool life, Taylor's tool life equation, effects of cutting parameters on tool life, cutting tool materials, Properties of cutting fluids. | 8 Hrs |

| | |
|---|---|
| **Desired properties and types of cutting tool materials** – HSS, carbides coated carbides, ceramics. Cutting fluids. Desired properties, types and selection. Heat generation in metal cutting, factors affecting heat generation. Heat distribution in tool and work piece and chip. Measurement of tool tip temperature.<br>**Laboratory Sessions/ Experimental learning:**<br>• Drawing of Merchant circle diagram extracting Cutting force and Thrust force using Tool dynamo meter.<br>**Applications:** All manufacturing industry.<br>**Video link / Additional online information:**<br>1. https://www.youtube.com/watch?v=-R-fySRLa9Q<br>2. https://www.youtube.com/watch?v=i06a7OnIkDk | |
| UNIT-II | |
| Turning Machine: Classification of Lathe, Driving mechanisms of lathe, constructional features of different types of lathe, different operations on lathe, Tool Layout.<br>Shaping Machine, Planing Machine, driving mechanism, different operations on shaping machine and planing machine, Simple problems on machining time calculations.<br>**Applications:** All manufacturing industry<br>**Video link / Additional online information:**<br>1. https://www.youtube.com/watch?v=Rf90Jbbcr3M<br>2. https://www.youtube.com/watch?v=IR2KhMTl5RM | 8 Hrs |
| UNIT-III | |
| **Drilling Machines:** Constructional features (Radial & Bench drilling Machines), operations, types of drill & drill bit nomenclature. Calculation of machining time.<br>**Milling Machines:** constructional features (Column and knee and vertical. Milling Machine), milling cutters nomenclature, milling operations, calculation of machining time. | 8 Hrs |

| | |
|---|---|
| **Grinding**: Types of Abrasives and bonding, grinding wheel nomenclature, mounting, truing and dressing of grinding wheels, different types of grinding machines.<br>**Introduction to lapping, honing and broaching.**<br>**Laboratory Sessions/ Experimental learning**:<br>Indexing in gear cutting operation can be performed using the milling machine with varying number of gear teeth in gear.<br>**Applications**: All manufacturing industry<br>**Video link / Additional online information**:<br>1. https://www.youtube.com/watch?v=Rf90Jbbcr3M<br>2. https://www.youtube.com/watch?v=IR2KhMTl5RM | |
| UNIT-IV | |
| **Gear Cutting Technology**<br>**Gear Milling**: Gear milling machine, worm gear milling, bevel gear milling, milling cutters. **Indexing**: Simple, compound, differential and angular indexing calculations. Simple numerical on indexing.<br>**Gear Hobbing**: Principle of Hobbing process, advantages and limitations of Hobbing process. Hobbing techniques, Hobbing cycles, Hobbing of Worm Wheels.<br>**Gear Shaping**: Principle of Gear shaping process, advantages and limitations, Helical Gear shaping:<br>Relationship between cutter teeth and helical guide.<br>**Gear Finishing Process**: Gear Shaving, Gear Lapping and Gear Grinding, Gear burnishing, Gear Honning.<br>**Laboratory Sessions/ Experimental learning**:<br>• Gear cutting can be practiced using shaper machine.<br>**Applications**: Power transmission industry.<br>**Video link / Additional online information**:<br>https://www.youtube.com/watch?v=B8w-0Oi0Yf4 | 8 Hrs |
| UNIT-V | |

| | |
|---|---|
| *Non-Conventional Machining Processes:*<br>Need for non traditional machining, Principle, equipment & operation of Laser Beam, Plasma Arc Machining, Electro Chemical Machining, Ultrasonic Machining, Abrasive Jet Machining, Water Jet Machining, Electron Beam Machining, Electron Discharge Machining and Plasma Arc Machining.<br>**Applications**: An ultrasonic tool essentially creates many small vibrations that, over time, remove material from the workpiece with which it's used<br>https://www.engineeringchoice.com/what-is-ultrasonic-machining/<br>**Video link / Additional online information:**<br>Introduction to Non-Traditional Machining by Dr. A k Sharma Department of Mechanical Engineering, IIT Kanpur.<br>https://www.bing.com/videos/search?q=NPTEL+Ultrasonic+machining&docid=603500698202029147&mid=E2D0437D56F63E9FCA93E2D0437D56F63E9FCA93&view=detail&FORM=VIRE<br>**Applications**: Automobile industry, Aerospace Industry, all type of sheet metal industry.<br>**Video link / Additional online information:**<br>https://www.youtube.com/watch?v=JgNaSll8Obo | 8 Hrs |
| Practical Experiments – Lab Sessions | 26 Hrs. |
| 1. Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning.<br>2. Cutting of V Groove/ dovetail / Rectangular groove using a shaper.<br>3. Cutting of Gear Teeth using Milling Machine.<br>4. Preparation of at least two fitting joint models by proficient handling and application of hand tools- V block, marking gauge, files, hack saw, drills etc. | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Students will able to understand Merchants circle diagram. |
| CO2 | Students able to understand the theory of metal cutting. |
| CO3 | Able to understand removal of metal using a cutting tool. |
| CO4 | Students will study about milling drilling and grinding machines. |
| CO5 | Analyse and understand Gear cutting technology. |

| Reference Books | |
|---|---|
| 1. | William K Dalton, Gregg Bruce R, "Modern Materials and Manufacturing |

| | |
|---|---|
| | **Processes",** Pearson Education, 2007 |
| 2. | **Rao P N, "Manufacturing Technology",** Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998. |
| 3. | **Production Technology: HMT** Tata McGraw Hill Publishing Co. Ltd.,New Delhi, 1999. |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the timetable and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students must answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three subdivisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 2 | 2 | 2 | - | - | - | 2 | 1 | 2 | 1 |
| CO2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | - | 2 | 2 | 1 | 2 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 1 | - | - | 2 | 1 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | - | 2 | 2 | 2 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 3 | 2 | 3 | 3 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| Fluid Mechanics (Theory and Practice) | | |
| Course Code: MVJ22ME43 | | CIE Marks:50+50 |
| Credits: L: T:P: 3:0:2 | | SEE Marks: 50 +50 |
| Hours:40 L+ 26 P | | SEE Duration: 03+03 Hours |

| Course Learning Objectives: The students will be able to | |
|---|---|
| 1 | Understand the properties of fluids and concept of control volume are studied. |
| 2 | Enumerate the applications of the conservation laws to flow through pipe. |
| 3 | Enumerate the applications of the conservation laws to flow through pipe. |
| 4 | Elucidate the importance of various types of flow in pumps. |
| 5 | Elucidate the importance of various types of flow in turbine. |

| UNIT-I | |
|---|---|
| **Fluid Properties and Flow Characteristics:** Dimensions and units: physical properties of fluids- specific gravity, viscosity and its significance, surface tension, capillarity, vapor pressure. Atmospheric gauge and vacuum pressure –measurement of pressure. Manometers Piezometer, U-tube, inverted and differential manometers. Pascal's law, hydrostatic law. **Buoyancy and floatation:** Meta center, stability of floating body. Submerged bodies. Calculation of metacenter height. Stability analysis and applications. | 08 h |
| UNIT-II | |
| **Fluid Dynamics:** Forces acting on fluid in motion, Linear momentum equation, Impact of jets, Moment of momentum equation, Euler's equation of motion along a streamline, Bernoulli's equation – assumptions and limitations. Introduction to Navier-Stokes equation, Venturi-meters, orifice meters, rectangular and triangular notches, pitot tubes, Rota-meter, electromagnetic flow meter **Boundary Layer Theory:** Introduction, momentum integral equation, displacement, momentum and energy thickness, separation of boundary layer, control of flow separation, Stream lined body, Bluff body and its applications, basic concepts of velocity profiles | 08 h |
| UNIT-III | |
| **Fluid kinematics:** Introduction, flow types. Equation of continuity for one dimensional flow, circulation and vorticity, Streamline, path line and streak lines and stream tube. Stream function and velocity potential | 08 h |

| | |
|---|---|
| function, differences, and relation between them. Condition for irrotational flow, flow net, source and sink, doublet, and vortex flow.<br>**Dimensional Analysis**: Similitude and modelling – Dimensionless numbers<br>**Closed conduit flow**: Reynold's experiment- Darcy Weisbach equation- Minor losses in pipes- pipes in series and pipes in parallel- total energy line-hydraulic gradient line. | |
| UNIT-IV | |
| **Basics of turbo machinery**: Hydrodynamic force of jets on stationary and moving flat, inclined, and curved vanes, jet striking centrally and at tip, velocity diagrams, work done and efficiency, flow over radial vanes, hydrodynamic force of jets on stationary and moving flat, inclined, and curved vanes, jet striking centrally and at tip, velocity diagrams, work done and efficiency, flow over radial vanes.<br>**Centrifugal pumps**: classification, working, work done – manometric head- losses and efficiencies- specific speed- pumps in series and parallel-performance characteristic curves, cavitation & NPSH, reciprocating pumps: Working, Discharge, slip, indicator diagrams. | 08 h |
| UNIT-V | |
| **Hydraulic Turbines**: Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis's turbine and Kaplan turbine-working proportions, work done, efficiencies, hydraulic design –draft tube- theory functions and efficiency. Performance of hydraulic turbines: Geometric similarity, Unit and specific quantities, characteristic curves, governing of turbines, selection of type of turbine, cavitation, surge tank, water hammer. Hydraulic systems hydraulic ram, hydraulic lift, hydraulic coupling. Fluidics – amplifiers, sensors, and oscillators. Advantages, limitations, and applications. | 08 h |
| LABORATORY EXPERIMENTS | |
| 1. Determination of coefficient of friction of flow in a pipe.<br>2. Determination of minor losses in flow through pipes.<br>3. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades.<br>4. Determination of coefficient of discharge of various flow measuring devices.<br>5. Performance studies on Pelton, Francis, and Kaplan wheel turbines.<br>6. Performance of Single and Multistage Centrifugal Pump.<br>7. Performance test on Reciprocating Pump.<br>8. Performance test on a two stage Reciprocating Air Compressor.<br>9. Performance test on an Air Blower.<br><br>**Any 10 experiments to be conducted** | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Acquire the knowledge of the basic principles of fluid mechanics and fluid kinematics. |
| CO2 | Acquire the basic knowledge of fluid dynamics and flow measuring instruments. |
| CO3 | Acquire the knowledge on the nature of flow and flow over bodies and the dimensionless analysis. |
| CO4 | Elucidate the concepts of the turbomachinery and their applications. |
| CO5 | Conduct basic experiments of fluid mechanics and hydraulic machinery and understand the working principles. |

| Reference Books | |
|---|---|
| 1 | Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi, 2013. ISBN 13: 9788189401269 |
| 2 | Kumar K. L., "Engineering Fluid Mechanics", Eurasia Publishing House(p) Ltd., New Delhi, 2016. ISBN 13: 9788121901000 |
| 3. | A textbook of Fluid Mechanics and Hydraulic Machines, Dr. R K Bansal, Laxmi publishers. ISBN 13: 9788131808153 |
| 4. | P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008. ISBN : 9788120332812 |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Laboratory- 50 Marks

The laboratory session is held every week as per the timetable and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students must answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three subdivisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | | | | | | | | | | | 2 |
| CO2 | 3 | 2 | 2 | 2 | | | 1 | | 2 | 1 | 2 | |
| CO3 | 3 | | | | | | | | 2 | | 2 | |
| CO4 | 3 | 2 | 2 | | | 2 | | | 2 | | | 2 |
| CO5 | 2 | | | | | | | | | | 2 | |

| | | | |
|---|---|---|---|
| Course Title | MECHANICAL MEASUREMENTS AND METROLOGY LAB | Semester | IV |
| Course Code | MVJ22MEL44 | CIE | 50 |
| Total No. of Contact | 40 L : T : P :: 00: 10: 30 | SEE | 50 |
| No. of Contact | 3 | Total | 100 |
| Credits | 01 | Exam. Duration | 3 hrs |

Course objective is to:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To provide students with the necessary skills for calibration and testing of different gauges and Instruments.
- To provide students with the necessary skills to collect data, perform analysis and

| EXPERIMENTS | |
|---|---|
| PART-A | |
| 1. | Calibration of Pressure Gauge |
| 2. | Calibration of Thermocouple |
| 3. | Calibration of LVDT |
| 4. | Calibration of Load cell |
| 5. | Determination of modulus of elasticity of a mild steel specimen using strain gauges |
| PART-B | |
| 6 | Measurements using Optical Projector / Toolmakers' Microscope |
| 7 | Measurement of angle using Sine Centre / Sine bar / bevel protractor |
| 8 | Measurement of alignment using Autocollimator / Roller set |
| 9 | Measurements of surface roughness using Tally Surf/Mechanical Comparator |
| 10 | Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer |
| 11 | Calibration of Micrometer using slip gauges |
| 12 | Measurements of Screw thread parameters using two wire or three-wire methods |

Course outcomes:

| | |
|---|---|
| CO1 | Demonstrate the necessary skills for calibration and testing of different gauges and instruments. |
| CO2 | Apply concepts of Measurement of angle using Sine Centre/ Sine Bar/ Bevel Protractor, Alignment using Autocollimator/ Roller set. |
| CO3 | Demonstrate measurements using Optical Projector/Tool maker microscope. |
| CO4 | Analyse Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometre |
| CO5 | Demonstrate the necessary skills to collect data, perform analysis and interpret results to draw valid conclusions through standard test procedures using various |

| Reference Books: | |
|---|---|
| 1. | Beckwith Marangoni and Lienhard *"Mechanical Measurements"* Pearson Education 6th Ed., 2006. |

Continuous Internal Evaluation (CIE):

Laboratory- 50 Marks

The laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of the marks over number of weeks is considered for 30 marks. At the end of the semester a test is conducted for 10 marks. The students are encouraged to implement additional innovative experiments in the lab and are awarded 10 marks. Total marks for the laboratory is 50.

Semester End Examination (SEE):
Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | | | | | | | | | | |
| CO2 | 2 | | 2 | 2 | | | 1 | | | | 2 | 2 |
| CO3 | 3 | 2 | | | | | | | | 2 | 1 | |
| CO4 | 3 | 2 | | 2 | | 2 | | | | | | 2 |
| CO5 | 2 | | 2 | | | | | | | | | |

| | | | |
|---|---|---|---|
| Course Title | PYTHON FOR MECHANICAL ENGINEERS | Semester | IV |
| Course Code | MVJ22ME451 | CIE | 50 |
| Total No. of Contact Hours | 40 L:T: P:: 3:0:0 | SEE | 50 |
| No. of Contact Hours/week | 03 | Total | 100 |
| Credits | 03 | Exam. Duration | 03 hrs |

Course objective is to:

- To understand the basics of algorithmic and flow chart for problem solving
- To learn to solve problems using Python basics of Data expression and Statements
- To learn to solve problems using Python conditionals
- To learn to solve problems using Python loops
- To use Python data structures – lists, tuples, dictionaries to represent complex data.

| UNIT – 1 | 08Hrs. |
|---|---|

**Introduction to Programming**: Meaning of problem solving, Definition of programming, Software bug, Programming errors, Natural language v/s Formal language, Programming Paradigm, interpreted v/s compiled, typed v/s type-less programming language. Algorithms: Definition, characteristics, Building blocks of Algorithms, Pseudo-code, flowcharts, Algorithmic problem solving, Simple strategies for developing algorithms, Mechanical Engineering Solved examples .

Video link / Additional online information:

Programming, Data Structures and Algorithms using Python By Madhavan Mukund
https://nptel.ac.in/courses/106106145

Programming in Python by Dr.Rizzwan Rehman

https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

| UNIT – 2 | 08Hrs. |
|---|---|

**Introduction to Python**: History, Salient features, Working with IDLE. Data expression and Statements: Variable and assignment, python data types, operators in python. Mechanical Engineering Applications (Flowchart, algorithm and program)

Video link / Additional online information:

Programming, Data Structures and Algorithms using Python By Madhavan Mukund

https://nptel.ac.in/courses/106106145

Programming in Python by Dr.Rizzwan Rehman

https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

| UNIT – 3 | 08Hrs. |
|---|---|

**Boolean values and Operators, Decision making**: if statement syntax, simple Programs (including algorithm and flow chart) If-else syntax, flow chart, simple Programs (including algorithm and flow chart) If-elif-else, syntax, flowchart, Mechanical Engineering Applications (Flowchart, algorithm and program)

Video link / Additional online information:
Programming, Data Structures and Algorithms using Python By Madhavan Mukund
https://nptel.ac.in/courses/106106145

Programming in Python by Dr.Rizzwan Rehman

https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

| UNIT – 4 | 08Hrs. |
|---|---|

**Iteration** : state, while loop: syntax, flowchart, simple Programs (including algorithm and flow chart) for loop: syntax, flow chart. Mechanical Engineering Applications (Flowchart, algorithm and program)

Video link / Additional online information:
Programming, Data Structures and Algorithms using Python By Madhavan Mukund
https://nptel.ac.in/courses/106106145

Programming in Python by Dr.Rizzwan Rehman

https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

| UNIT – 5 | 08Hrs. |
|---|---|

**Lists and Tuples** : List methods, Processing lists, nested lists, tuples. Programs on lists and tuples. Introductions to functions, syntax, simple programs on functions, Sharing python code using modules.

Video link / Additional online information:
Programming, Data Structures and Algorithms using Python By Madhavan Mukund
https://nptel.ac.in/courses/106106145

Programming in Python by Dr.Rizzwan Rehman

https://onlinecourses.swayam2.ac.in/cec22_cs20/preview

| Course Outcomes: | |
|---|---|
| CO1 | Develops algorithms and flowcharts for problem solving. |

| | |
|---|---|
| CO2 | Develop programs by using Data expression and Statements, loops |
| CO3 | Demonstrate proficiency in handling python conditionals and identify the methods to create and manipulate lists, tuples. |

| Text Books: | |
|---|---|
| 1 | Al Sweigart, "Automate the Boring Stuff with Python",1stEdition, No Starch Press, 2015.<br><br>(Available under CC-BY-NC-SA license at https://automatetheboringstuff.com/) |
| 2 | S.A. Kulkarni, "Problem solving and python programming", 2nd edition Yesdee publishing pvt. Ltd. 2019 |
| Reference Books | |
| 1 | Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Green Tea Press, 2015. |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 2 | 1 | 2 | 3 | - | - | - | - | - | - | - | 2 |
| CO2 | 2 | 1 | 1 | 1 | - | - | - | - | - | - | - | 2 |
| CO3 | 2 | 1 | 2 | 2 | - | - | - | - | - | - | - | 2 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| Precision Engineering and Nano Fabrication<br>(Theory) | | |
| Course Code: MVJ22ME452 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40 L | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | Learn and understand basic concepts & definitions of precision engineering | |

| | |
|---|---|
| 2 | Make selection of the type of microfabrication technique required for any specific product |
| 3 | Know about the special microfabrication and gauging when their use is warranted. |

| UNIT-I | |
|---|---|
| **Introduction** – Precision, Accuracy & Smoothness – Need – Development of overall machining precision Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility.<br><br>**Experiential Learning**: High precision machining of components in machine shop lab<br>**Video Links/Any other special information**:<br>https://nptel.ac.in/courses/112105231 | 8 Hrs |
| **UNIT-II** | |
| **Precision machine element**<br>Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers – Rolling elements– hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings.<br>**Experiential Learning**: High precision machining of components in machine shop lab<br>**Video link / Additional online information**:<br>https://nptel.ac.in/courses/112105231 | 8 Hrs |
| **UNIT-III** | |
| **Error Control**: Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control errors due to locations – principle of constant location surfaces.<br>**Experiential Learning**: High precision machining of components in machine shop lab<br>**Video link / Additional online information**:<br>https://nptel.ac.in/courses/112105231 | 8 Hrs |
| **UNIT-IV** | |
| **Micro and Nano fabrication**<br>Micro and Nano machining processes-diamond machining - micro engraving - Micro replication techniques forming-casting-injection moulding - micro embossing - Energy assisted processes LBM, EBM, FIB, Micro electro discharge machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition.<br>**Experiential Learning**: Micro manufacturing of silicon wafer based components in chemistry lab.<br>**Video link / Additional online information**:<br>https://nptel.ac.in/courses/112105231 | 8 Hrs |

| UNIT-V | |
|---|---|
| **Nano Machining**: Laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerization, Micro and Nano welding: Micro and Nano welding in similar and dissimilar materials; welding processes like ultrasonic, EB, LB; applications. Micro and Nano casting: Casting processes like vacuum, semi-solid state; applications.<br>Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, Impurity introduction, Thermal oxidation, CVD, Metallization etc. IC packaging<br>**Experiential learning**:<br>• Etching of the different substrate materials in clean room<br>**Video link / Additional online information**:<br>https://nptel.ac.in/courses/112105231 | 8 Hrs |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Appreciate the meaning of precision machining and the importance of it. |
| CO2 | Get familiarized with the requirements of machine network elements to achieve precision in the components. |
| CO3 | Appraise the principles of various precision engineering processes and apply them in actual field. |
| CO4 | Appreciate the various method of micro and nanomachining using LASER and other processes. |
| CO5 | Appraise the Application of ultra-precision manufacturing for producing precise components |

| Reference Books | |
|---|---|
| 1. | Venkatesh V.C. and Izman S., Precision Engineering, Tata McGraw Hill, 2007. |
| 2. | Murthy R.L., Precision Engineering, New Age International, 2009. |
| 3. | Nakazawa H., Principles of Precision Engineering, Oxford University Press, 1994. |

**Continuous Internal Evaluation (CIE):**

**Theory for 50 Marks**

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

**Semester End Examination (SEE):**

Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO2 | 3 | 3 | 2 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Semester: IV | | |
|---|---|---|
| Micro Electro Mechanical Systems<br>(Theory) | | |
| Course Code: MVJ22ME453 | | CIE Marks: 50 |
| Credits: L:T:P: 3:0:0 | | SEE Marks: 50 |
| Hours: 40 L | | SEE Duration: 03 Hours |
| Course Learning Objectives: The students will be able to | | |
| 1 | Give an insight into the history and latest developments regarding MEMS | |
| 2 | Appreciate piezoelectric and magnetic sensing and actuation. | |
| 3 | Elucidate the importance of measurement, signal processing, drive and control techniques | |
| 4 | Elucidate the concept of Signal Processing, Drive and Control Techniques. | |
| 5 | Explicate the concepts of MEMS and Microfabrication. | |

| | |
|---|---|
| UNIT-I | |
| **MEMS**: History of MEMS, Intrinsic Characteristics, and Devices: Sensors and Actuators. Microfabrication: Photolithography, Thermal oxidation, Thin film deposition, etching types, Doping, Dicing, Bonding. Microelectronics fabrication process flow, Silicon based, Process selection and design.<br>**Experiential Learning**: Demonstration of functioning of sensors and actuators in MEMS devices<br>**Video Links/Any other special information:**<br>1 https://nptel.ac.in/courses/117105082<br>2https://archive.nptel.ac.in/courses/108/108/108108113/ | 8 Hrs |
| UNIT-II | |
| **Piezoelectric and Magnetic Sensing and Actuation**: Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles.<br>**Experiential Learning**: Demonstration of the concepts of piezoelectric and mangetic sensing and actuation.<br>**Video Links/Any other special information:**<br>1 https://nptel.ac.in/courses/117105082<br>2https://archive.nptel.ac.in/courses/108/108/108108113/ | 8 Hrs |
| UNIT-III | |
| **Measurement, Signal Processing, Drive and Control Techniques**: Quasi -static and Dynamic Measurement Methods; Signal conditioning devices; Constant voltage, Constant-current and Pulse drive methods; Calibration methods; Structural dynamics and Identification techniques; Passive, Semi -active and Active control; Feedback and feed forward/control strategies.<br>**Experiential Learning**: Demonstration of measurement, signal process drive and control techniques<br>**Video Links/Any other special information:**<br>1 https://nptel.ac.in/courses/117105082<br>2https://archive.nptel.ac.in/courses/108/108/108108113/ | 8 Hrs |
| UNIT-IV | |
| **Data Acquisition and Processing** – Signal Processing and Control for Smart Structures – Sensors as Geometrical Processors – Signal Processing – Control System – Linear and Non-Linear.<br>**Experiential Learning**: Data acquisition and signal processing using NI-LAB VIEW Software<br>**Video Links/Any other special information:**<br>1 https://nptel.ac.in/courses/117105082<br>2https://archive.nptel.ac.in/courses/108/108/108108113/ | 8 Hrs |
| UNIT-V | |
| Case Studies: | 8 Hrs |

| | |
|---|---|
| MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyroscopes.<br>**MEMS Micro manufacturing and Product development**: Bulk and Surface Micromachining, The LIGA Process, MEMS product development- Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties, Investment and competition.<br>**Experiential Learning**: Preparation of product development plan for MEMS devices considering all the concepts of product development.<br>**Video Links/Any other special information:**<br>1 https://nptel.ac.in/courses/117105082<br>2https://archive.nptel.ac.in/courses/108/108/108108113/ | |

| Course Outcomes: After completing the course, the students will be able to | |
|---|---|
| CO1 | Define the basic concepts of MEMS and latest developments in the domain |
| CO2 | Understand Design, Analysis, Manufacturing and Applications of MEMS Products |
| CO3 | Appreciate the application of MEMS devices in real time. |
| CO4 | Apply the principle of Measurement, Signal Processing, Drive and Control Techniques in their projects. |
| CO5 | Apply the knowledge of MEMS and MEMS fabrication techniques in real time. |

| Reference Books | |
|---|---|
| 1. | V. K. Varadan, K. J. Vinoy, S. Gopalakrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and Sons, England, 2006. |
| 2. | Manouchehr E. Motamedi, "MOEMS: Micro-Opto-Electro-Mechanical Systems" New Age International Publishers, 2010 (ISBN-13 : 978-8122428339) |
| 3. | Chang Liu "Foundation of MEMS", Pearson Education. (ISBN:9788131764756) |

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the self -study are 20 (2 presentations are be held for 10 marks each). The marks obtained in test, quiz and self -studies are added to get marks out of 100 and report CIE for 50 marks.

Semester End Examination (SEE):

Total marks: 50+50=100

SEE for 50 marks are executed by means of an examination.

The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | | | | | | | | | | | 2 |
| CO2 | 3 | 2 | 2 | 2 | | | 1 | | 2 | 1 | 2 | |
| CO3 | 3 | | | | | | | | 2 | | 2 | |
| CO4 | 3 | 2 | 2 | | | 2 | | | 2 | | | 2 |
| CO5 | 2 | | | | | | | | | | 2 | |

| Semester: IV | | |
|---|---|---|
| Robotics and Automation (Theory) | | |
| Course Code: MVJ22ME454 | | CIE Marks:50 |
| Credits: L:T:P:S: 3:0:0 | | SEE Marks: 50 |
| Hours: 40 L | | SEE Duration: 3 Hrs |
| Course Learning Objectives: The students will be able to | | |
| 1 | To Familiarize with anatomy, specifications and types of Robots | |
| 2 | Obtain forward and inverse kinematic models of robotic manipulators | |
| 3 | Develop dynamic model and design the controller for robotic manipulators | |
| 4 | Choose appropriate Robotic configuration and list the technical specifications forrobots used in different applications | |
| 5 | Familiarize with different types of mobile robots, kinematic models, motion control and sensors for mobile robots | |

| UNIT-I | |
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| Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations- PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist; Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, | 8 Hrs |

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| Active and passive grippers, selection and design considerations of grippers in robot. | |
| UNIT-II | |
| Robot Kinematics Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous coordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF) Inverse kinematics- general properties of solutions, Problems (upto 3DOF) Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only) | 8 Hrs |
| UNIT-III | |
| Trajectory planning Tasks◊Path planning◊ Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, Point to point vs continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms. | 8 Hrs |
| UNIT-IV | |
| Manipulator Dynamics Lagrange'sformulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots upto 2 DOF, modelling including motor and gearbox. Robot Control The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control. | 8 Hrs |
| UNIT-V | |
| Industrial Applications-Material handling, welding, Spray painting, Machining. Case studyfor robotic applications including robot selection considerations for a typical industrial<br><br>Robotics & Automation<br><br>Application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability,<br><br>Precision and Accuracy, Operating environment. foreg – the robotic configuration for pick and place robot, spot welding robot in a car manufacturing industry, peg in hole assembly.<br><br>Applications in the medical, mining, space, defence, security, domestic, entertainment. | 8 Hrs |

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| Course Outcomes: After completing the course, the students will be able to |

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| CO1 | Differentiate between open and closed kinematic chain with the help of examples. |
| CO2 | Differentiate between reachable and dexterous workspace. |
| CO3 | Differentiate between path and trajectory of a robotic manipulator |
| CO4 | dynamic model of robotic manipulators |
| CO5 | Characteristics of a spray painting robot. |

| Reference Books | |
|---|---|
| 1. | Robert. J. Schilling , "Fundamentals of robotics – Analysis and control", Prentice Hall of India 1996. |
| 2. | Introduction to Robotics ( Mechanics and control), John. J. Craig, Pearson Education Asia 2002. |
| 3. | Introduction to Robotics by S K Saha, Mc Graw Hill Education |
| 4. | Robotics Technology and Flexible Automation, Second Edition, S. R. Deb |
| Web links and Video Lectures (e-Resources): <br> https://archive.nptel.ac.in/courses/112/105/112105249/ <br> https://onlinecourses.nptel.ac.in/noc21_me76/preview | |

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Semester End Examination (SEE):
Total marks: 50+50=100

SEE for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 1 | 2 | 1 | - | - | 3 | - | 1 |
| CO2 | 3 | 2 | 2 | 2 | 2 | - | 1 | - | - | - | 3 | 1 |
| CO3 | 3 | 2 | 1 | - | 2 | - | - | - | - | - | - | 1 |
| CO4 | 3 | 2 | 1 | 3 | 3 | - | 2 | - | - | - | - | 1 |
| CO5 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | - | - | - | - | 1 |