Semester: III		
Transforms and Statistical Methods (Theory)		
Course Code	MVJ21MA31A	CIE Marks: 50
Credits	L:T:P:: 3:2:0	SEE Marks: 50
Hours	30L+20T	SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Comprehend and use of analytical and numerical methods in different engineering fields.	
2	Apprehend and apply Fourier Series.	
3	Realize and use of Fourier transforms.	
4	Realize and use of Z-Transforms.	
5	Use of statistical methods in curve fitting applications.	

UNIT-I	
Laplace Transform: Definition and Laplace transforms of elementary functions. Laplace transforms of Periodic functions and unit-step function and problems. **Inverse Laplace Transform**: Definition and problems, Convolution theorem to find the inverse Laplace transforms and problems. **Applications**: Solution of linear differential equations using Laplace transforms. Self study topic: Derivations of Laplace transforms of elementary functions, Unit impulse function-problems. **Web Link and Video Lectures**: https://nptel.ac.in/courses/111106139	10 Hrs
UNIT-II	
Fourier series: Recapitulation of Series, Continuous and Discontinuous functions, Periodic functions, Dirichlet's condition, Fourier series of periodic functions of period 2π and arbitrary period $2l$, Half-range Fourier sine and cosine series, Practical Harmonic Analysis and Problems. **Web Link and Video Lectures**: https://nptel.ac.in/courses/111106111/	10 Hrs
UNIT-III	
Fourier transforms: Infinite Fourier transform, Infinite Fourier sine and cosine transforms, Inverse Fourier transforms, Inverse Fourier sine and cosine transforms, Convolution theorem. **Web Link and Video Lectures**: https://nptel.ac.in/courses/111105123	10 Hrs
UNIT-IV	
Z-Transforms: Difference equations, basic definition, Z-transform -definition,	10 Hrs

Properties of Z-transforms, Standard Z-transforms, damping rule, Shifting rule, Initial value and final value theorems - problems, Inverse Z-transform. **Applications**: Application of Z- transforms to solve difference equations. Self study topic: Proof of Initial value and final value theorems. **Web Link and Video Lectures**: https://nptel.ac.in/courses/108104100	
UNIT-V	
Curve Fitting: Curve fitting by the method of least squares. Fitting of the curves of the form $y = ax + b$, $y = ax^2 + bx + c$, $y = ae^{bx}$. **Statistical Methods**: Introduction, Correlation and coefficient of correlation, Regression, lines of regression and problems. Self study topic: Fitting of the curves of the form $\boldsymbol{y = ax^b}$. **Web Link and Video Lectures**: https://nptel.ac.in/courses/111105042	10 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Use Laplace transform and inverse transforms techniques in solving differential equations.
CO2	Communications, Know the use of periodic signals and Fourier series to analyze circuits and system.
CO3	Demonstrate Fourier Transform as a tool for solving Integral equations.
CO4	Apply Z Transform to solve Difference Equation.Use Method of Least Square for appropriate Curves.
CO5	Fit a suitable curve by the method of least squares and determine the lines of regression for a set of statistical data.

Reference Books	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10th edition,2014.
3.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
4.	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition.

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

High-3, Medium-2, Low-1

Semester: III		
ENGINEERING THERMODYNAMICS (Theory)		
Course Code: MVJ21ME32		CIE Marks:50
Credits: L:T:P:S: 4:0:0		SEE Marks: 50
Hours: 50L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
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 apply thermodynamics principles to air standard cycles with the help of PV and Ts diagrams
4	To be able to apply thermodynamics principles to vapor power cycles
5	To be able to make performance analysis of reciprocating air compressors 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 *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. **Experiential Learning**: IC Engines, Thermometers, Dynamometer, Compressors etc. **Video Links/Any other special information:** 1. https://www.youtube.com/watch?v=WFMIzS2jQQg&t=48s 2. https://nptel.ac.in/courses/112105123	10 Hrs
UNIT-II	
Pure substances: Definition, phase change of a pure substance, Phase change terminology & definitions, Important terms relating to steam formation. p-V, T-s and h-s diagrams. (No numerical examples) **Ideal & Real Gases**: Introduction and definition of ideal gas, The equation of state of a perfect gas, Specific heat capacities. Introduction and definition of real gases, Van der Waal's equation, Reduced properties, Law of corresponding states, Compressibility charts. (No numerical examples) **Experiential Learning:** Steam formation experimentation in lab. **Video link / Additional online information:** 1. https://youtu.be/wjvIZDwIKaE 2. https://youtu.be/HoodenvNcTc 3. https://youtu.be/tlaKcBB_C9E 4. https://youtu.be/BKLW0MyoyAg 5. https://www.youtube.com/watch?v=HoodenvNcTc	10 Hrs

UNIT-III	
First Law of Thermodynamics: Statement of the First law of thermodynamics, energy, energy as a property, modes of energy, Specific heat at constant volume, enthalpy, specific heat constant pressure. steady state-steady flow energy equation, important applications. *Second Law of Thermodynamics:* Thermal reservoir. Direct heat engine; schematic representation and efficiency. Reserved heat engine, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamic; PMM I & PMM II Clausius's statement of Second law of Reversible and irreversible processes; Introduction to Entropy, its importance and definition (No derivations) **Experiential Learning**: Compressors, Turbines, IC engines, Refrigerator, Heat Pump etc **Video Links/Any other special information**: 1. https://www.youtube.com/watch?v=10FlW80XN64 2. https://nptel.ac.in/courses/112104113/ 3. https://www.youtube.com/watch?v=cobFAMZDS0o 4. 2. https://nptel.ac.in/courses/112108148/	10 Hrs
UNIT-IV	
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.). **Vapor Power Cycle**: Steam power plant, Ideal and actual Rankine Cycles. Effect of pressure and temperature on Rankine cycle performance. Reheat Cycle, Ideal Regenerative Cycle, Regenerative Cycle with feed water heaters. Binary Vapor Cycle. Problems. **Experiential Learning**: Heat engines of all types form a very important and commercially used application based on thermodynamic principles. **Video link / Additional online information**: 1. https://youtu.be/LDXLOCTeJQE, 2. https://youtu.be/b5SPb6NHna4, 3. https://youtu.be/PB7n8Y74890 4. https://youtu.be/4-BI22Wx4Pc, 5. https://youtu.be/vt1_7f5l3hI, 6. https://youtu.be/NtoTpeWAAWc	10 Hrs
UNIT-V	
Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression. **Experiential learning**: • Performance analysis of air compressor will be analyzed by conducting the experiment related to air compressor available in Fluid mechanics and machines laboratory. **Video link / Additional online information**: 1. https://youtu.be/zX8PnPCGRLE	10 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 pure substance, real and ideal gases and its use in thermodynamics
CO3	Understand first & second laws of TD, Entropy and its applications
CO4	Application of TD to air standard. And Vapor power cycles,
CO5	Application of TD to reciprocating air compressors

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		
Mechanics of Materials (Theory)		
Course Code: MVJ21ME33		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 study the distribution of various stresses in mechanical elements that deform under various loads.	

UNIT-I	
Stresses and Strains: Stress and strain due to axial force, elastic limit, Hooke's law-factor of safety - stepped bars, uniformly varying sections, stresses in composite bar due to axial force and temperature. Strain Energy due to axial force- proof resilience, stresses due to gradual load, sudden load and impact load. **Experiential Learning:** The material property like modulus of elasticity can also be found for different engineering materials like copper, bronze, aluminium apart from mild steel (Material testing lab can be used). **Applications**: The students will be asked to find stresses and strains induced in various applications like, chair/bench where the students are sitting, strain in the shoe while jogging, in the concrete building etc **Video link**: https://www.mtu.edu/materials/k12/experiments/tensile/.	8 Hrs
UNIT-II	
Changes in Dimensions and Volume: Lateral strain - Poisson's ratio, volumetric strain, changes in dimensions and volume, shear stress, shear strain, relationship between elastic constants. Hoop and Longitudinal stresses in thin cylindrical and spherical shells under internal pressure-changes in dimensions and volume. **Experiential Learning:** A practical observation of strain gauges will be given, one of the most important sensors of the electrical measurement technique applied to the measurement of mechanical quantities like forces, pressure etc (metrology and measurement lab can be used). **Applications**: Change in dimensions in all three directions for different geometrical cross sections like square, rectangle can be found for a minimum two different materials. **Video link**: https://www.youtube.com/watch?v=qHi8FPnWP6E	8 Hrs
UNIT-III	
Principal Stresses and Strains: (Two dimensional only) State of stress at	Hrs

a point - normal and tangential stresses on a given plane, principal stresses and their planes, plane of maximum shear stress, analytical method, Mohr's circle method, application to simple problems, Strain Rosettes. **Experiential Learning:** Material subjected to 2D state of stress (wood and ply wood) and its analysis can be thought using Ansys software under static condition (Computer Aided Modelling and Analysis lab can be used). **Applications:** Mohr's circle can be used to find the principal plane in wood materials. **Videolink:** https://www.youtube.com/watch?v=wbkvJmUEKHY	
UNIT-IV	
Bending Moment and Shear Force: Relationship between load, shear force and bending moment -shear force and bending moment diagrams for cantilever, simply supported and overhanging beams under concentrated loads, uniformly distributed loads,uniformly varying loads, concentrated moments, maximum bending moment and point of contra flexure. *Flexure in Beams:* Theory of simple bending and assumptions - derivation of equation, section modulus, normal stresses due to flexure. **Experiential Learning:** A cantilever and simply supported beam subjected to different types of loads like point load, UDL, UVL couple can be thought using Ansys software under static condition (Computer Aided Modelling and Analysis lab can be used). **Applications:** The importance of the beam cross section for a particular loading. **Video link:** https://www.youtube.com/watch?v=-9DYHrqq51E	Hrs
UNIT-V	
Deflection of Determinate Beams: Governing differential equation - Macaulay's method-moment area method, application to simple problems; Bending moment and shear force diagram of a typical shaft, elastic instability, Euler Formula. *Torsion:* Theory of torsion and assumptions-derivation of the equation, polar modulus, stresses in solid and hollow circular shafts, power transmitted by a shaft, close coiled helical spring with axial load. **Experiential Learning:** Dynamic analysis of a shaft subjected to torque can be thought using Ansys software (Computer Aided Modelling and Analysis lab can be used). **Applications:** A propeller shaft of an automobile which transmits power and motion from engine to the wheels. **Video link:** https://www.youtube.com/watch?v=cZwg6XYpzRw	Hrs

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		
Materials Engineering (Theory and Practice)		
Course Code: MVJ21ME34		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. **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. **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. **Powder metallurgy**: Introduction, Powder Production Techniques: Different Mechanical and Chemical methods, Characterization of powders (Particle Size & Shape Distribution), Powder Shaping: Particle Packing Modifications,	8 Hrs

Lubricants & Binders, Powder Compaction & Process, Sintering and Application of Powder Metallurgy.	
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. **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; Aluminium Alloys, Magnesium Alloys, Nickel based super alloys and Titanium alloys. **Composite Materials**: Introduction, Classification, Metal Matrix Composites, Ceramic Matrix Composites, Polymer Matrix Composites, Natural fiber reinforced composites, Advantages, Limitations, Properties and Applications.	8 Hrs
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.
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 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):

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.

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			
Manufacturing Technology-Theory and Practice (Theory and Practice)			
Course Code: MVJ21ME35			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	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 furnaces. Determine the appropriate parameters for different manufacturing processes. Justify the most appropriate manufacturing process for a given product.		
3	Recognize the importance of metal joining processes in fabrication and categorize different processes.		
4	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.		
5	Categorize and describe various sheet metal operations and their advantages and limitations.		

UNIT-I	
Manufacturing Process: Introduction to basic manufacturing, Classification of manufacturing process, Primary and Secondary Manufacturing process classification and Applications, Primary manufacturing process of Iron and Aluminium, Introduction about metal casting. **Pattern Making:** Functions of pattern, Classification of pattern, Different pattern materials, various pattern allowances in design of pattern, Simple problems in design of pattern.	8 Hrs
UNIT-II	
Mould Making: Moulding sand ingredients, Desirable properties of Sand Mould, cores and functions of cores, types of Moulds, Mould making, moulding machines. Concept of gating system, different types of gating systems, gating system design, risering design. **Special casting processes:** Shell moulding, investment casting, Gravity die casting, Pressure die casting, Centrifugal casting, Continuous casting, Injection moulding, Blow Moulding, Defects in casting, Causes, features and remedies.	8 Hrs
UNIT-III	
Metal Joining (Welding): Survey of welding and allied processes. Gas welding and cutting, process and equipment. Arc welding: Power sources and consumables. TIG & MIG processes and their parameters. Resistance welding-spot, seam projection, Other welding processes such as atomic hydrogen, submerged arc, electroslag, friction welding. **Other types of Metal Joining and Welding defects:** Soldering & Brazing. Adhesive bonding, Riveting and Bolting.	8 Hrs

Heat Affected Zone, Weld decay in HAZ, Defects in welding, causes features and remedies, Welding Inspection - Visual, Magnetic particle, Fluorescent particle, Ultrasonic, Radiography, Eddy current, Holography methods of Inspection.	
UNIT-IV	
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. **Forging**: Introduction, Classification of Forging, Die Forging with Power Hammers, Open Die Forging, Impression Die Forging, Closed Die Forging, Forging Defects. **Rolling**: Introduction, Nomenclature of Rolled Products, Mechanism of Rolling, and Types of Rolling Mill, Rolls and Roll Pass Design, Ring Rolling, Cold Rolling.	8 Hrs
UNIT-V	
Drawing: Drawing equipment & dies, expression for drawing load by slab analysis, power requirement. Redundant work and its estimation, optimal cone angle & dead zone formation, drawing variables, Tube drawing, classification of tube drawing, simple problems. **Extrusion**: Types of extrusion processes, extrusion equipment & dies, deformation, lubrication & defects in extrusion. Extrusion dies, Extrusion of seamless tubes. Extrusion variables, simple problem. **Sheet Metal Forming**: Introduction, Dies & punches, Types of presses, piercing, blanking, bending, deep drawing, LDR in drawing, Forming limit criterion, defects of drawn products, stretch forming. Roll bending & contouring, Simple problems	8 Hrs
LABORATORY EXPERIMENTS	
1. Compression strength test of Moulding Sand 2. Shear strength test of Moulding Sand 3. Tensile strength test of Moulding Sand 4. Permeability test of Moulding Sand 5. Clay content test of Moulding Sand 6. Grain fineness test by Sieve Analysis. 7. Making a mould cavity using two hand cut molds 8. Making a mould cavity using single piece pattern and split pattern 9. Calculation of length of the raw material required to prepare the model considering scale loss, preparation of square shaped and bend 10. Calculation of length of the raw material required to prepare the model considering scale loss and preparation of square headed stud 11. L joint, T joint and Butt joint preparation using arc welding equipment on M.S. flats 12. V joint and Lap joint welded joints using arc welding equipment on M.S. flats	

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	Categorize and explain all the special casting processes and Press and Die punch assembly
CO3	Understand the principles of metal joining processes and the constructional features of the equipment.
CO4	Identify and explain the principle behind metal forming process and detail all the forging and rolling process.
CO5	Carryout sand tests, simple moulding and forging operations.

Reference Books	
1.	O.P Khanna, "Foundry Technology", Dhanpat rai publications-2003 reprint ISBN-10 8189928341
2.	R.K Jain , Production Technology Vol. 1, Khanna Publishers, ISBN 9788174090991
3.	P N Rao, "Manufacturing Technology: Foundry, Forming and Welding", 2nd Edition Tata Mc Graw-Hill Publication. ISBN:9789383286621, 9383286628

Web links and Video Lectures (e-Resources):

1. Principles of Metal Forming Technology, Mechanical Engineering. Dr. Pradeep K. Jha IIT Roorkee, Video Lecture. https://nptel.ac.in/courses/112/107/112107250/

2. Metal Casting, Dr. Pradeep Kumar, Dr. D. B. Karunakar, IIT Roorkee, https://archive.nptel.ac.in/courses/112/107/112107083/

3. Joining Technologies for metals, Prof. Dheerendra Kumar Dwivedi, IIT Roorkee, https://nptel.ac.in/courses/112107213

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 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):

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.

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									

Semester: III		
SAMSKRUTHIKA KANNADA (Theory)		
Course Code: MVJ21KAN36		CIE Marks: 50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 15L		SEE Duration: 02 Hrs.
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		

UNIT-I	
೧. ಕನ್ನಡ ಭಾಷೆ-ಸಂಕ್ಷಿಪ್ತ ವಿವರಣೆ. ೨. ಭಾಷಾ ಪ್ರಯೋಗಲ್ಲಾಗುವ ಲೋಪದೋಷಗಳು ಮತ್ತು ಅವುಗಳ ನಿವಾರಣೆ	3 Hrs
UNIT-II	
೧. ಲೇಖನ ಚಿಹ್ನೆಗಳು ಮತ್ತು ಅವುಗಳ ಉಪಯೋಗ ೨. ಪತ್ರ ವ್ಯವಹಾರ.	3 Hrs.
UNIT-III	
೧. ಆಡಳಿತ ಪತ್ರಗಳು. ೨. ಸರ್ಕಾರದಆದೇಶ ಪತ್ರಗಳು	3 Hrs.
UNIT-IV	
೧. ಸಂಕೀಪ್ತ ಪ್ರಬಂಧರಚನೆ, ಪ್ರಬಂಧ ಮತ್ತು ಭಾಷಾಂತರ ೨. ಕನ್ನಡ ಶಬ್ದಸಂಗ್ರಹ	3 Hrs.
UNIT-V	
೧. ಕಂಪ್ಯೂಟರ್ ಹಾಗೂ ಮಾಹಿತಿತಂತ್ರಜ್ಞಾನ ೨. ಪಾರಿಭಾಷಿಕ ಆಡಳಿತ ಕನ್ನಡ ಪದಗಳು ಮತ್ತು ತಾಂತ್ರಿಕ/ಕಂಪ್ಯೂಟರ್ ಪಾರಿಭಾಷಿಕ ಪದಗಳು.	3 Hrs.

Reference Books	
5.	Adalitha Kannada – Dr. L Thimmesh, Prof. V Keshav Murthy

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE for 50 marks, executed by way of tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 40 marks and assignment is evaluated for 10 marks. The three tests are conducted for 40 marks each and the average of all the tests are calculated for 40. The marks for the assignments are 10 (2 assignments for 5 marks each). The marks obtained in test and assignment are added and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks, executed by means of an examination. The Question paper contains objective type questions for 50 marks covering the entire syllabus having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

Semester: III		
BALIKE KANNADA (Theory)		
Course Code: MVJ21KAN36		CIE Marks: 50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 15L		SEE Duration: 02 Hrs.
Course Learning Objectives: This course will enable students to understand Kannada and communicate in Kannada language		

UNIT-I	
Vyavharika Kannada –Parichaya (Introduction to Vyavharika Kannada)	3 Hrs
UNIT-II	
Kannada Aksharamaale haagu uchcharane(Kannada Alphabets and Pronunciation)	3 Hrs.
UNIT-III	
Sambhashanegaagi Kannada Padagalu (Kannada Vocubulary for Communication).	3 Hrs.
UNIT-IV	
Kannada Grammar in Conversations(Sambhasaneyalli Kannada Vyakarana)	3 Hrs.
UNIT-V	
Activities in Kannada	3 Hrs.

Reference Books	
1.	Adalitha Kannada – Dr. L Thimmesh, Prof. V Keshav Murthy

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE for 50 marks, executed by way of tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 40 marks and assignment is evaluated for 10 marks. The three tests are conducted for 40 marks each and the average of all the tests are calculated for 40. The marks for the assignments are 10 (2 assignments for 5 marks each). The marks obtained in test and assignment are added and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks, executed by means of an examination. The Question paper contains objective type questions for 50 marks covering the entire syllabus having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

Semester: III		
Spread Sheet for Engineers (AEC)		
Course Code: MVJ21MEA37		CIE Marks: 50
Credits: L: T:P: 1:0:2		SEE Marks: 50
Hours: 15 L+20 P		SEE Duration: 03 Hours

Course Learning Objectives: The students will be able to	
1	To create different plots and charts. To compute different functions, conditional functions and make regression analysis.
2	To carryout iterative solutions for roots, multiple roots, optimization and non-linear regression analysis.
3	To carryout matrix operations and athematic operations.
4	To Understand VBA and UDF and to understand VBA subroutines and Macros.
5	To carryout numerical integration and solving differential equations using different methods.

UNIT-I	
Charting: Create an XY scatter graph, XY chart with two Y-Axes, add error bars to your plot, create a combination chart. Functions: Computing Sum, Average, Count, Max and Min, Computing Weighted Average, Trigonometric Functions, Exponential Functions, Using the CONVERT Function to Convert Units. Laboratory Sessions/ Experimental learning: Plotting Stress Strain Diagrams for the given set of stress strain values. Applications: Converting the data to charts and data visualization. Video link / Additional online information: https://onlinecourses.nptel.ac.in/noc21_ge21/preview https://www.coursera.org/specializations/excel-data-analytics-visualization https://www.youtube.com/watch?v=VjQgeP6yb9A	7 Hrs
UNIT-II	
Conditional Functions: Logical Expressions, Boolean Functions, IF Function, Creating a Quadratic Equation Solver, Table VLOOKUP Function, AND, OR and XOR functions. Regression Analysis: Trendline, Slope and Intercept, Interpolation and Forecast, The LINEST Function, Multilinear Regression, Polynomial Fit Functions, Residuals Plot, Slope and Tangent, Analysis Tool Pack. Laboratory Sessions/ Experimental learning: Multilinear regression analysis for curve fitting of Load versus Displacement. Applications: Curve fitting and prediction and forecasting. Video link / Additional online information: https://onlinecourses.nptel.ac.in/noc22_mg35/preview https://nptel.ac.in/courses/111105042	7 Hrs

https://archive.nptel.ac.in/courses/110/107/110107092/ https://www.youtube.com/watch?v=0ienbLvFddQ	
UNIT-III	
Iterative Solutions Using Excel: Using Goal Seek in Excel, Using the Solver to Find Roots, Finding Multiple Roots, Optimization Using the Solver, Minimization Analysis, Non-Linear Regression Analysis. Matrix Operations Using Excel: Adding Two Matrices, multiplying a Matrix by a Scalar, Multiplying Two Matrices, transposing a Matrix, inverting a Matrix and Solving System of Linear Equations. Laboratory Sessions/ Experimental learning: Optimization of Mathematical models / Regression equations developed for a given set of load displacement values. Applications: Finding the maximum and minimum in a given set of values and optimization studies. Video link / Additional online information: https://archive.nptel.ac.in/courses/110/107/110107157/ http://www.nitttrc.edu.in/nptel/courses/video/110104119/L22.html https://freevideolectures.com/course/4743/nptel-supply-chain-analytics/27	7 Hrs
UNIT-IV	
VBA User-Defined Functions (UDF): The Visual Basic Editor (VBE), The IF Structure, The Select Case Structure, the for Next Structure, The Do Loop Structure, Declaring Variables and Data Types, An Array Function the Excel Object Model, For Each Next Structure. VBA Subroutines or Macros: Recording a Macro, coding a Macro Finding Roots by Bisection, Using Arrays, adding a Control and Creating User Forms. Laboratory Sessions/ Experimental learning: To setup the velocity of the falling parachutist. Applications: For automating using Macro fictions and automating the data sorting and other data operations. Video link / Additional online information: https://www.coursera.org/learn/excel-vba-for-creative-problem-solving-part-1 https://onlinecourses.nptel.ac.in/noc22_cs71/preview http://nptel.ac.in/courses/Webcoursecontents/IIScBANG/Operating%20Systems/New_index1.html	7 Hrs
UNIT-V	
Numerical Integration Using Excel: The Rectangle Rule, The Trapezoid Rule, The Simpson's Rule, creating a User-Defined Function Using the Simpson's Rule. Differential Equations: Euler's Method, Modified Euler's Method, The Runge Kutta Method, Solving a Second Order Differential Equation. Laboratory Sessions/ Experimental learning: Numerical Integration to find the Nusselt number.	7 Hrs

Applications: To find out different numerical correlational among experimental factors / variables. Video link / Additional online information: https://archive.nptel.ac.in/courses/102/106/102106051/ https://archive.nptel.ac.in/courses/103/106/103106120/ https://archive.nptel.ac.in/courses/103/103/103103162/	

Course Outcomes: After completing the course, the students will be able to	
CO1	To create different plots and charts.
CO2	To compute different functions, conditional functions and make regression analysis.
CO3	To carryout iterative solutions for roots, multiple roots, optimization and non-linear regression analysis and to carryout matrix operations.
CO4	To Understand VBA and UDF & To understand VBA subroutines and Macros.
CO5	To carryout numerical integration and solving differential equations using different methods.

Reference Books	
6.	Excel 2019 All-In-One: Master the New Features of Excel 2019 / Office 365 Paperback – 1 January 2019 by Lokesh Lalwani. ISBN: 978-9388511582.
7.	Advance Excel 2019 Training Guide: Tips and Tricks to Kick Start Your Excel Skills Paperback – 1 January 2019 by Manish Nigam, ISBN: 978-9388176675.
8.	Excel Macros for Dummies, 2nd edition, Michael Alexander, 978-8126575282
9.	MICROSOFT EXCEL 2019: DATA ANALYSIS&BUSINESS MODEL: Data Analysis and Business Modeling Paperback – 11 October 2019, L. Winston Wayne , 978-9389347180

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):

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								2
CO2	3	2	2		2		1		2	1	2	
CO3	3	2									2	
CO4	3	2	2			2			2			2
CO5	2			2							2	

Semester: III		
Additional Mathematics-I (Common to all branches)		
Course Code:	MVJ21MATDIP1	CIE Marks:50
Credits:	L:T:P:S: 4:0:0:0	SEE Marks: 50
Hours:	40L	SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	To familiarize the important and introductory concepts of Differential calculus	
2	Aims to provide essential concepts integral calculus	
3	To gain knowledge of vector differentiation	
4	To learn basic study of probability	
5	Ordinary differential equations of first order and analyze the engineering problems.	

UNIT-I	
Differential calculus: Recapitulation of successive differentiation -nth derivative -Leibnitz theorem (without proof) and Problems, Polar curves - angle between the radius vector and tangent, angle between two curves, pedal equation, Taylor's and Maclaurin's series expansions- Illustrative examples. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs
UNIT-II	
Integral Calculus: Statement of reduction formulae for the integrals of $\sin^n(x)$, $\cos^n(x)$, $\sin^n(x)\cos^n(n)$ and evaluation of these integrals with standard limits-problems. Double and triple integrals-Simple examples. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs
UNIT-III	
Vector Differentiation: Scalar and Vector point functions, Gradient, Divergence, Curl, Solenoidal and Irrotational vector fields. Vector identities - $div(\phi\vec{A})$, $curl(\phi\vec{A})$, $curl(grad(\phi))$, $div(curl\vec{A})$. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs
UNIT-IV	
Probability: Basic terminology, Sample space and events. Axioms of probability. Conditional probability – illustrative examples. Bayes theorem-examples. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs
UNIT-V	
Ordinary Differential Equations of First Order: Introduction – Formation of differential equation, solutions of first order and first degree differential equations: variable separable form, homogeneous, exact, linear differential equations. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the knowledge of calculus to solve problems related to polar curves and its applications
CO2	Apply the concept of integration and variables to evaluate multiple integrals and their usage in computing the area and volumes.
CO3	Illustrate the applications of multivariate calculus to understand the solenoidal and irrotational vectors and also exhibit the inter dependence of line, surface and volume integrals.
CO4	Understand the basic Concepts of Probability
CO5	Recognize and solve first-order ordinary differential equations occurring in different branches of engineering.

Reference Books	
1.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd Edition, 2013, .
2.	G. B. Gururajachar, Calculus and Linear Algebra, Academic Excellent Series Publicatior 2018-19
3.	Chandrashekar K. S, Engineering Mathematics-I, Sudha Publications, 2010.

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

Semester: IV		
Complex Variables and Numerical Methods (Theory)		
Course Code	MVJ21MA41A	CIE Marks: 50
Credits	L:T:P:: 2:2:0	SEE Marks: 50
Hours	20L+20T	SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Understand the concepts of Complex variables and transformation for solving Engineering Problems.	
2	Understand the concepts of complex integration, Poles and Residuals in the stability analysis of engineering problems.	
3	Apply the concept to find extremal of functionals.	
4	Solve initial value problems using appropriate numerical methods.	
5	Students learn to obtain solutions of ordinary and partial differential equations numerically.	

UNIT-I	
Complex variables - I: Functions of complex variables, Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Consequences of Cauchy-Riemann Equations, Construction of analytic functions (Using Milne-Thomson method). **Transformations**: Bilinear Transformation, Conformal transformation, Discussion of the transformations $w = z^2$, $w = e^z$ and $w = z + \frac{a}{z}, (z \neq 0)$. **Self Study topic** : Harmonic function and its properties **Web Link and Video Lectures**: https://nptel.ac.in/courses/111103070	8 Hrs
UNIT-II	
Complex variables-II: Complex integration - Cauchy theorem, Cauchy's Integral Theorem-Problems, Taylor & Laurent series- Problems, Singularities, Types of Singularities, Poles, Residues-definitions, Cauchy residue theorem - Problems. **Self Study topic**: Consequences of Cauchy's theorem, Cauchy residue theorem. **Web Link and Video Lectures**: https://nptel.ac.in/courses/111103070	8 Hrs
UNIT-III	
Numerical methods-I: Numerical solution of Ordinary Differential Equations of first order and first degree, Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order, Milne's and Adam-Bashforth Predictor and Corrector method. **Web Link and Video Lectures**: https://nptel.ac.in/courses/127106019	8 Hrs
UNIT-IV	

Numerical methods-II: Numerical solution of Ordinary Differential Equations of second order: Runge-Kutta method of fourth order, Milne's Predictor and Corrector method. **Calculus of variations**: Variation of function and Functional, variational problems, Euler's equation, Geodesics. **Applications** : Hanging Chain problem. **Self Study topic** : Adam-Bashforth Predictor and Corrector method. **Web Link and Video Lectures:** https://nptel.ac.in/courses/127106019 https://nptel.ac.in/courses/111107103	8 Hrs
UNIT-V	
Numerical methods-III: Numerical solution of Partial Differential Equations: Introduction, Finite difference approximations to derivatives, Explicit methods-Numerical Solution of Laplace Equation, Numerical solution of one-dimensional heat equation by Bender - Schmidt's method and by Crank-Nicholson Method, Implicit method-Numerical solution of one-dimensional wave equation. **Self Study topic**: Classification of Partial differential equations, Parabolic, Elliptic and Hyperbolic equations. **Web Link and Video Lectures:** https://nptel.ac.in/courses/111107063	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	State and prove Cauchy - Riemann equation with its consequences and demonstrate Con-formal Transformation.
CO2	Illustrate Complex Integration using Cauchy's Integral theorem, Cauchy's Integral formula and Cauchy's Residue theorem.
CO3	Identify appropriate numerical methods to solve ODE.
CO4	Determine the extremals of functionals and solve the simple problems of the calculus of variations.
CO5	Choose appropriate numerical methods to solve Partial Differential Equations.

Reference Books	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10th edition,2014.
3.	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
4.	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition.

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

High-3, Medium-2, Low-1

Semester: IV		
THEORY OF MACHINES (Theory)		
Course Code: MVJ21ME42		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03
Course Learning Objectives: The students will be able to		
1	Explain the types of relative motion to differentiate between Machine, Mechanism, and Structure	
2	Draw velocity and acceleration diagrams of linkages.	
3	Determine gear parameters and determine train value & fixing torque in gear trains.	
4	Design Cam profile for the desired follower motion.	

UNIT-I	
Introduction: Definition of link, pair, kinematic chain, mechanism, machine, inversion, structure – Types of motion, Grashof's criterion, Inversions of 4 bar chain, single slider crank chain and double slider crank chain – Degrees of freedom – Gruebler's criterion for mobility of mechanisms. **Mechanisms**: Drag link and toggle mechanisms – Straight line mechanisms, Condition for exact straight line motion, Peaucellier and Hart mechanisms – Intermittent motion mechanisms, Ratchet and pawl and Geneva wheel – Pantograph, Condition for perfect steering, Steering gear mechanisms, Ackermann– Hooke's joint, Oldham's Coupling.	8 Hrs
UNIT-II	
Velocity and Acceleration: Determination of velocity and acceleration of a point/link in simple mechanisms by relative velocity method (graphical) – Coriolis component of acceleration. **Instantaneous centre** – Centrodes – Kennedy's theorem – To determine linear velocity and angular velocity of links of simple mechanisms by instantaneous centre method. Klein's Construction for velocity and acceleration of slider crank mechanism.	8 Hrs
UNIT-III	
Spur Gear: Classification of toothed wheels – Gear terminology –Law of gearing –Velocity of sliding – Length of path of contact, Arc of contact – Contact ratio – Interference in involute gears, Methods of avoiding interference –Minimum number of teeth to avoid interference on pinion meshing with gear and on pinion meshing with rack. Characteristics of involutes action, Comparison of involute and cycloidal teeth profiles. Numerical problems.	8 Hrs
UNIT-IV	
Gear Trains–Velocity ratio & Train value, Types of gear trains– Simple, Compound, Reverted & Epicyclic gear trains. Algebraic/Tabular method of finding Train value of Epicyclic gear trains. Numerical problems.	8 Hrs
UNIT-V	
Cams: Types of cams, Types of followers and types of follower motion – Displacement, velocity and acceleration curves for SHM, Uniform velocity, UARM and Cycloidal motion – To draw cam profile for disc cam with reciprocating	8 Hrs

follower (knife edge, roller and flat faced)– To find maximum velocity and acceleration in each case.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Define the basic mechanisms for developing a machine.
CO2	Construct velocity and acceleration diagram for mechanism.
CO3	Design and synthesize mechanisms for specific type of relative motion.
CO4	Estimate kinematic parameters for industrial mechanism of gears.
CO5	Construct the Cams for various followers.

Reference Books	
1.	S S RATHAN: "Text Book of Theory of Machines", 4th Edition, McGraw-Hill Education,(INDIA) private limited , ISBN 007-059120-2
2.	SADHU SINGH : "Theory of Machines", 2nd Edition, Pearson Education Publications, 2007, ISBN-13 : 978-8177581270
3.	R S KHURMI, J K GUPTA: "A Text Book of Theory of Machines", S CHAND publication. ISBN-13:978-8121910019
4.	GHOSH A. AND MALLICK A.K : "Theory of Mechanisms and Machines", Affiliated East-West Pvt. Ltd, New Delhi, 1988. ISBN-13:978-8185938936

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112105268/
2. https://swayam.gov.in/nd1-noc20-me21/
3. https://nptel.ac.in/courses/1121/104/112104121/
4. https://nptel.ac.in/courses/1121/104/112104121/
5. https: //nptel.ac.in/courses/1121/104/112104121/

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

Semester: IV		
Advanced Manufacturing Technology (Theory)		
Course Code: MVJ21ME43		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	Recognize the mechanics of machining processes and cutting tool materials.
2	Recognize the different machine tool types and parts and operational features.
3	Write part programs using G codes and M codes for different part profiles.
4	Recognize the different high energy rate forming and additive manufacturing techniques.
5	Elucidate advanced machining processes and micro machining and nano machining techniques.

UNIT-I	
Mechanics of Machining Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built- Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Numericals. **Cutting Tool Materials**: Geometry and Surface Finish, desirable Properties and Characteristics of cutting tool materials, cutting tool geometry, Tool Life and Machinability, cutting fluids and its applications, surface finish, effect of machining parameters on surface finish.	8 Hrs
UNIT-II	
Lathe and Milling Machine: Lathe, Types, Construction, Operations, Advantages and Limitations. Milling Machine, Types, Construction, Operations, Advantages and Limitations. Cutting Speed, Feed, Depth of cut, Machining Time and Cost Calculations. **Drilling and Reciprocating Machine**: Drilling Machine, Types, Construction, Operations, Advantages and Limitations. Shaper – Types, Construction, Operations, Advantages and Limitations. Cutting Speed, Feed, Depth of cut, Machining Time and Cost Calculations.	8 Hrs
UNIT-III	
CNC Tooling and Programming: CNC Tooling, Tool and work holding devices, Automatic Tool Changers, Automatic Pallet Changers. CNC Programming: Introduction-G Codes and M Codes, Part Program and its elements, Methods of Programming: Manual and Computer Assisted Part programming, APT language.	8 Hrs
UNIT-IV	
High Energy Rate Forming Methods: Principles, advantages and applications, explosive forming, electro hydraulic forming, Electromagnetic forming. **Introduction to Additive Manufacturing**: Definition, Classification of Additive Manufacturing Processes-Process parameters, Advantages, Limitations and Applications.	8 Hrs
UNIT-V	

Advanced Machining Processes: Abrasive Jet Machining, Water Jet Machining, Abrasive Water Jet Machining, Ultrasonic Machining, Electrical Discharge Machining, Electro-chemical machining (ECM), Laser Beam Machining (LBM), Plasma Arc Machining (PAM) and Electron Beam Machining. **Micro Machining and Nano Machining**: Micro Machining and Nano Machining, Types, Process parameters, Advantages, Limitations, and Applications.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the principle of machining and mechanics of metal cutting
CO2	Identify and explain the principle behind operations of lathe and milling machines.
CO3	Understand G codes, M codes and write simple programs for turning and milling operations.
CO4	Understand the process of High Energy Rate forming methods.
CO5	Categorize and explain the non-conventional Machining Process and its applications.

Reference Books	
1.	M. C. Shaw, Theory of Metal Cutting, Oxford and I.B.H. Publishing, 1st edition, 1994.
2.	Milkell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, John Wiley and Sons, New Jersey, 4th edition, 2010.
3.	P.C. Pandey and H. S. Shan, "Modern Machining Process", Tata McGraw-Hill Publishing company Ltd. 33rd Reprint.
4.	Hajra Choudhury S K, Elements of Workshop Technology Vol 2 Machine Tools Paperback – 1 January 2010. Indian Book Distributing Co. Calcutta. ISBN-13 : 978-8185099156.

Web links and Video Lectures (e-Resources):

1. Introduction to Non-Traditional Machining by N. Sinha Department of Mechanical Engineering IIT Kanpur : Video Lecture -- https://nptel.ac.in/courses/112105212/
2. Metal Cutting and Machine Tools by Prof. Asimava Roy Choudhury, Department of Mechanical Engineering, IIT Kharagpur : Video Lecture -- https://archive.nptel.ac.in/courses/112/105/112105233/

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										2
CO2	3		2	2			1				2	1
CO3	2									2	1	2
CO4	3	2	1	2	1	2					2	2
CO5	2											1

Semester: IV		
Metrology and Measurements Theory and Practice		
Course Code: MVJ21ME44		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	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 measuring tools & measuring techniques along with understanding the calibration techniques of various measuring devices

UNIT-I	
Prerequisites: Basics of measurements and measuring systems. **Basic Concepts of Measurement and Metrology**: Definition and significance of measurement, Generalized measurement system, Performance characteristics of measuring instruments (Only static characteristics), Inaccuracy of Measurements, Definition and objectives of metrology. Standards, Subdivision of standards, Line and end standard, Imperial standard yard, Wave length standard, International Prototype meter, Transfer from line to end standard. Calibration of end bars, Slip gauges, Wringing phenomena, Numerical problems on building of slip gauges. **Laboratory Sessions/ Experimental learning**: • Building dimensions using slip gauges and angle gauges. **Applications**: Measurement and manufacturing of other processes, defect detection, Calibration and quality Control. **Video link / Additional online information** : https://lake.videoken.com/nptel/search/Metrology%20/video/BqAmlOl8uzs?tocitem=4	8 Hrs
UNIT-II	
Prerequisites: Basics of limits, types of fits, holes and shafts. **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. Classification of gauges, Basic concept of design of gauges (Taylor's principles), wear allowance on gauges. Types of gauges -plain plug gauge, ring gauge, snap gauge, gauge materials. Gauge Design and numerical problems. **Laboratory Sessions/ Experimental learning**:	8 Hrs

• Study and use of; plug gauge and ring gauges, calculation of wear allowance. **Applications**: Providing Allowances and clearance for various applications of holes and shafts. **Video link / Additional online information**: https://lake.videoken.com/nptel/search/System%20of%20Limits%20and%20Fits	
UNIT-III	
Prerequisites: Basics of comparators, pressure gauges, screw thread, and gears. **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. **Metrology of Screw Thread and Gear**: Measurement of basic elements of thread, Screw threads: 2- wire and 3-wire methods. Gear tooth terminology, Base-tangent method, Constant chord method, Measurement of pitch, Gear roll tester. Basic concepts of Coordinate measuring machines-construction and applications. **Laboratory Sessions/ Experimental learning**: • Study and Operation of different comparators and pressure gauge. • Experimental Verification of base tangent method and constant chord method. • Study of Coordinate measuring machines, its applications. • Measurement of screw thread and Gear parameters. **Applications**: Compare voltages and currents to measure minute and micro displacements. **Video link / Additional online information** : https://lake.videoken.com/nptel/search/Comparators%20	8 Hrs
UNIT-IV	
Prerequisites: Basic of sensors, transducers, amplifiers and CRO. **Transducers**: Introduction, Transfer efficiency, Loading effect, Primary and Secondary transducers, classification of transducers with examples. Advantages of each type transducers. 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. **Laboratory Sessions/ Experimental learning**: • Application of oscillograph and CRO. **Applications**: Automation and control of Electronic circuits, wireless communication and broadcasting. **Video link / Additional online information** : https://lake.videoken.com/nptel/search/Transducers/	8 Hrs
UNIT-V	
Prerequisites: Basic of strain, force, torque and temperature. **Strain Measurement**: Methods of strain measurement, Strain gauges, Preparation and mounting of strain gauges, Gauge factor. **Measurement of Force**: Introduction, Proving ring. **Measurement of Torque**: Introduction, Prony or Brake Dynamometer, Hydraulic dynamometer.	8 Hrs

Measurement of Pressure: Introduction, Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani Gauge. **Temperature Measurement**: Resistance thermometers, Wheatstone bridge circuit, Thermocouple, Laws of thermocouple, Thermocouple materials. Pyrometers, Optical pyrometers. **Laboratory Sessions/ Experimental learning**: • Study of strain gauge and application. Study of thermistors, resistance thermometers and its operation. Study of pyrometer, thermocouple and its use. **Applications**: measurement of strain in load bearing structures along load paths, temperature/pressure gradient in high pressure vessels. **Video link / Additional online information**: https://lake.videoken.com/nptel/search/Strain%20gauge/	

LABORATORY EXPERIMENTS

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.
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. Measurement using Optical Flats

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 Calibration of pressure gauge, thermocouple, LVDT, load cell, micrometer. Apply concepts of Measurement of angle using Sine Centre/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set. Demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats. Analyse tool forces using Lathe/Drill tool dynamometer. Analyse Screw thread parameters

	using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometer.

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.	**Richard S Figliola, Donald E Beasley "Theory and Design for Mechanical Measurements",** 3rd edition, WILEY India Publishers. ISBN-13 978-0471000891
4.	**R.K. Jain, "Engineering Metrology",** Khanna Publishers, Delhi, 2009. ISBN-13 978-8174091536

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 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):

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 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.

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									

Semester: IV		
Machine Drawing and Operations (Theory and Practice)		
Course Code: MVJ21ME45		CIE Marks:100
Credits: L:T:P: 3:0:2		SEE Marks: 100
Hours: 40L+26P		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 expose the students to CNC Machine Tools, CNC part programming	
3	To provide an insight to different machine tools, accessories and attachments.	

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. **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. **Laboratory Sessions/ Experimental learning**: Conversion ISO view to orthogonal view of different machine components to be done using available software tool in the lab. **Applications**: All manufacturing Industry. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=-_qz8_sbhwY 2. https://www.youtube.com/watch?v=zO8coRhrJM0	8 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. *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. **Laboratory Sessions/ Experimental learning**: 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. **Applications**: Assembly and sub assembly of components. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=TPURJnlekeo	8 Hrs

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 (Chain and zigzag using snap head riveters). Laboratory Sessions/ Experimental learning: Lap and Butt joint of different plate thickness are drawn using soft wear. Applications: Bridge construction, Boiler construction, Automobile sheet metal assembly. Video link / Additional online information: 1. https://www.youtube.com/watch?v=C5ZPaCvoigw	8 Hrs
UNIT-IV	
Joints: Cotter joint (socket and spigot), Knuckle joint (pin joint) for two rods. Laboratory Sessions/ Experimental learning: 2D Drawing are drawn using software & 3D individual parts are made and assembled as per given drawing. Applications: Power transmission assembly, Automobile (Heavy Trucks) industry. Video link / Additional online information: 1. https://www.youtube.com/watch?v=J9Aj17MAyLY 2. https://www.youtube.com/watch?v=esfr74WhbYg 3. https://www.youtube.com/watch?v=qjGF08LvZ9M	8 Hrs
UNIT-V	
Assembly Drawings: (Part drawings shall be given) 1. Plummer block (Pedestal Bearing) 2. I.C. Engine connecting rod 3. Screw jack (Bottle type) 4. Tailstock of lathe 5. Machine vice 6. Lathe square tool post Laboratory Sessions/ Experimental learning: 3D individual parts are made and assembled as per given drawing. Applications: Heavy equipment manufacturing, IC engine manufacturing, Automotive industry. Video link / Additional online information: 1. https://www.youtube.com/watch?v=boyN1l3fA6g&list=PLQL-DlNb9_TVqG1Zrw-9F-S0LItg3T5fD	8 Hrs

2. https://www.youtube.com/watch?v=yKl_FiUdAu4&list=PLQL-DlNb9_TUHs8CUXYw-Lna-Gp4rTu9g 3. https://www.youtube.com/watch?v=pyzsBiU-raE&list=PLQL-DlNb9_TXofoObUwlRjLzPst-sRbG3	

Laboratory Experiments

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.
2. Cutting of V Groove/ dovetail / Rectangular groove using a shaper.
3. Cutting of Gear Teeth using Milling Machine.
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.
5. CNC Part programming for turning operations using CAM simulation software
6. CNC Part programming for milling operations using CAM simulation software
7. Demonstration on CNC milling and turning operations.
8. Demonstration of Robot programming for pick and place and stacking operations.

Course Outcomes: After completing the course, the students will be able to	
CO1	Upon completion of this course, the students can able to apply mathematical knowledge to Calculate the deformation behaviour of simple structures.
CO2	Critically analyse problem and solve the problems related to mechanical elements and analyse the deformation behaviour for different types of loads.
CO3	Analyse the deflection in beams.
CO4	Analyse buckling and bending phenomenon in columns, struts and beams.
CO5	Analysis of shaft for various cross sections.

Reference Books	
1.	Serope Kalpakjian, Steuen. R, Sechmid, "Manufacturing Technology" Pearson Education Asia, 5th Ed. 2006.
2.	S. Trymbakaa Murthy, "A Text Book of Computer Aided Machine Drawing" CBS Publishers, New Delhi, 2007.
3.	Mikell P Groover, "*Automation, Production Systems and Computer-Integrated Manufacturing*", 4th Edition, 2015, Pearson Learning.
4.	**Computer Aided Machine Drawing** by K R Gopala Krishna, ASIN : B079Z9BG2L Publisher : Subhas Stores (1 January 2015)

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

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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

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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 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.

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

Semester: IV		
CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW (Theory)		
Course Code: MVJ21CPH46		CIE Marks:50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours:15L		SEE Duration: 02 Hours
Course Learning Objectives: The students will be able to		
1	To know the fundamental political codes, structure, procedures, powers, and duties of Indian constitution, Indian government institutions, fundamental rights, directive principles and the duties of the citizens.	
2	To provide overall legal literacy to the young technograts to manage complex societal issues in the present scenario.	
3	To understand engineering ethics & their responsibilities, identify their individual roles and ethical responsibilities towards society.	

UNIT-I	
Introduction to Indian Constitution The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian Constitution, The Making of the Constitution, The role of the Constituent Assembly – Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and Limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and Significance in Nation Building.	3Hrs
UNIT-II	
Union Executive and State Executive: Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Article 370, 371, 371J) for some States.	3Hrs
UNIT-III	
Elections, Amendments and Emergency Provisions: Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44,61,73,74,75,86, and 91,94,95,100,101,118 and some important Case Studies. Recent Amendments with explanation. Important Judgements with Explanation and its impact on society (from the list of Supreme Court Judgements). Emergency Provisions, types of Emergencies and it's consequences.	3Hrs

Constitutional Special Provisions: Special Constitutional Provisions for SC & ST, OBC, Special Provision for Women, Children & Backward Classes.	
UNIT-IV	
Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India) : Profession, Professionalism, Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering - Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.	3Hrs
UNIT-V	
Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship, Cybercrimes and enforcement agencies.	3Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Have constitutional knowledge and legal literacy
CO2	Understand Engineering and Professional ethics and responsibilities of Engineers.
CO3	Understand the cyber crimes and cyber laws for cyber safety measure.
Reference Books	
1.	Constitution of India and Professional Ethics, T.S. Anupama, Sunstar Publisher
2.	Durga Das Basu (DD Basu): "Introduction to the Constitution on India", (Students Edition.) Prentice –Hall EEE, 19th/20th Edn., (Latest Edition) or 2008.
3.	Shubham Singles, Charles E. Haries, and Et al : "Constitution of India and Professional Ethics" by Cengage Learning India Private Limited, Latest Edition – 2018.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE for 50 marks, executed by way of tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 40 marks and assignment is evaluated for 10 marks. The three tests are conducted for 40 marks each and the average of all the tests are calculated for 40. The marks for the assignments are 10 (2 assignments for 5 marks each). The marks obtained in test and assignment are added and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks, executed by means of an examination. The Question paper contains objective type questions for 50 marks covering the entire syllabus having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

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

Semester: IV		
Geometric Dimensioning and Tolerancing (AEC)		
Course Code: MVJ21MEA47		CIE Marks: 50
Credits: L:T:P: 1:0:2		SEE Marks: 50
Hours: 15L+20P		SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Define the geometry of model.	
2	Specify Dimensions on the model	
3	Specify All types of tolerances on the model	

UNIT-I	
Basic Concepts: General terms and definitions of geometrical features - General principle of sizes - System of limits and fits - Principles of dimensioning - Introduction to geometric dimensioning and tolerancing (GD&T) - Inspection of dimensional and geometrical deviations - Datums and datum systems Laboratory Sessions/ Experimental learning: Drawing Gear Components with basic GD&T Video link / Additional online information: https://www.youtube.com/watch?v=LClcXsvzUoY	7 Hrs
UNIT-II	
Form and Orientation Tolerances: Form tolerances: types, specifications and interpretations - measurement and evaluation of straightness, flatness and roundness - Orientation tolerances: types, specifications and interpretations, and verification of orientation tolerances. Laboratory Sessions/ Experimental learning: Providing Form and Orientation tolerances in Drawing sheet for a machine component. Video link / Additional online information: https://www.youtube.com/watch?v=-9Ixr0bw2Rk	7 Hrs
UNIT-III	
Location, Runout and Profile Tolerances: Tolerances of location: types, specifications and interpretations - verification techniques - Tolerances of profiles of lines and surfaces with or without datums - Tolerances of runout - Tolerancing of angles and cones. Laboratory Sessions/ Experimental learning: Providing Location, Runout and profile tolerances in Drawing sheet for a machine component. Video link / Additional online information: https://www.youtube.com/watch?v=jxwhF7hl0vo	7 Hrs
UNIT-IV	
Surface Roughness–Various parameters and their measurements in two dimensions - filtering and filtering techniques - areal parameters.	7 Hrs

Laboratory Sessions/ Experimental learning: Profilometer Experiment **Video link / Additional online information :** https://www.youtube.com/watch?v=dzhh82H2Nuk	
UNIT-V	
Related Topics: Vectorial dimensioning and tolerancing - Statistical tolerancing of mechanical assemblies - Dimensional chains - Measurement uncertainty - Computer-aided tolerancing and verification. **Video link / Additional online information:** https://www.youtube.com/watch?v=PcDaJBzSK90	7 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Systematically introduce the essentials of the language of geometric dimensioning and tolerancing (GD&T) based on ASME and ISO standards, as well as the essentials of surface roughness measurements in both 2D and 3D including filtering techniques
CO2	Systematically introduce the related concepts of Vectorial dimensioning and tolerancing, dimensional chains, measurement uncertainty, etc.
CO3	Get knowledge about the surface roughness
CO4	Gain knowledge about the statistical tolerance
CO5	The knowledge gained by the students by learning the above topics will help them to perform very well in their profession as metrologists as well as product designers.

Reference Books	
1.	GEOMETRIC DIMENSIONING & TOLERANCE (GD&T) REFERENCE GUIDE BOOK, edition, 1 January 2016
2.	Meadows, J. D., Geometric Dimensioning and Tolerancing: Applications and Techniques for use in Design, Manufacturing and Inspection, Marcel Dekker, Inc., New York. Edition, 4 May 1995
3.	Drake, P. J., Dimensioning and Tolerance Handbook, McGraw-Hill, 1st edition (16 November 1999)
4.	Gill, P. S., Geometric Dimensioning and Tolerancing, S. K. Kataria & Sons, New Delhi. Edition: 2nd Edition, 2013

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

Semester: IV		
SUMMER INTERNSHIP-I (Theory and Practice)		
Course Code: MVJ21INT48		CIE Marks: -
Credits: 02		SEE Marks: -
Hours: -		SEE Duration: -

Course Learning Objectives: The students will be able to	
1	Get an inside view of an industry and organization/company
2	Gain valuable skills and knowledge
3	Make professional connections and enhance student's network
4	Get experience in a field to allow the student to make a career transit
5	To build a record of work experience and construct a good relationship with the employers.

Guidelines

- Students have to undergo this training for a period of 4 weeks (minimum) during the vacation between even and odd semesters.
- The internship will be considered as a head of passing and will be considered for the award of the degree. Those who do not take up / complete the internship will be declared fail and will have to complete during the subsequent examination after satisfying the internship requirements.
- The department shall nominate a faculty as a mentor for a group of students to prepare and monitor the progress of the students
- The students shall report the progress of the internship to the mentor/guide at regular intervals and may seek his/her advice.
- After completion of Internship, students shall submit a report to the department with the approval of both internal and external guides/mentors.
- Evaluation of Internship shall be conducted during VIII semester by internal and external examiners for 100 marks.
- The external examiner shall be from the industry where the student carried out the internship. In case of non-availability of external examiner, the concerned head of the department shall appoint an external examiner from the nearby college or a senior faculty member from outside the department in consultation with respective BOE and approved by Principal
- The internship carries three credits. A student has to get a minimum of 40% marks for a pass. If the student fails to complete the same then internship has to be repeated in its entirely
- The breakup of marks for the evaluation of training is as in table.

Evaluation by the supervisor under whom the training was carried out	25 Marks
Evaluation by DSEC	
1. Relevance of the Field training/Industrial Internship	10 Marks
2. Report	25 Marks
3. Evaluation	40 Marks
Total	100

Course outcomes:	
CO1	To experience a 4 weeks' internship training, enabling the student for onsite visits, study projects and practical training.
CO2	To develop a skill for handling multiple situations, practical problems, analyzing teamwork and communication abilities
CO3	To integrate theory with practice and carry out performance objectives on strong work ethics, persistence, adaptability and critical
CO4	To analyze work environment and create solution to problems.
CO5	To build a record of work experience and construct a good relationship facilitating him to become a team player in his career.

Reference Books:	
1	T1.Pamela Myers Kiser, "Human Services Internship: Getting the Most From Your Experience", Cengage Learning, 4th Edition, 2016. (ISBN13: 978-1305087347)
2	T3.H. Frederick Sweitzer, "Successful Internship", Brooks/Cole Publishing Co., 5th Edition, 2019.
3	R1. Bill Hobbs, Zach Schleien, "Hacking the Internship Process (Work)", La Plata Press, Paperback, 2017.

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

High-3, Medium-2, Low-1

Semester: IV		
Additional Mathematics-II (Common to all branches)		
Course Code:	MVJ21MATDIP2	CIE Marks:50
Credits:	L:T:P:S: 4:0:0:0	SEE Marks: 50
Hours:	40L	SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	To familiarize the important concepts of linear algebra.	
2	Aims to provide essential concepts differential calculus, beta and gamma functions.	
3	Introductory concepts of three-dimensional geometry along with methods to solve them.	
4	Linear differential equations	
5	Formation of partial differential equations.	

UNIT-I	
Linear Algebra: Introduction - Rank of matrix by elementary row operations - Echelon form. Consistency of system of linear equations - Gauss elimination method. Eigen values and eigen vectors of a square matrix. Diagonalization of a square matrix of order two. **Self study**: Application of Cayley-Hamilton theorem (without proof) to compute the inverse of a matrix-Examples. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs
UNIT-II	
Differential calculus: Indeterminate forms: L-Hospital rule (without proof), Total derivatives, and Composite functions. Maxima and minima for a function of two variables. **Beta and Gamma functions:** Beta and Gamma functions, Relation between Beta and Gamma function-simple problems. **Self study**: Curve tracing. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8Hrs
UNIT-III	
Analytical solid geometry : Introduction –Directional cosine and Directional ratio of a line, Equation of line in space- differentforms, Angle between two line, shortest distance between two line, plane and equation of plane in different forms and problems. **Self study**: Volume tetrahedron. **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8Hrs
UNIT-IV	
Differential Equations of higher order: Linear differential equations of second and higher order equations with constant coefficients. Inverse Differential	8 Hrs

operator, Operators methods for finding particular integrals , and Euler – Cauchy equation. **Self study**: Method of variation of parameters **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	
UNIT-V	
Partial differential equation: Introduction- Classification of partial differential equations, formation of partial differential equations. Method of elimination of arbitrary constants and functions. Solutions of non-homogeneous partial differential equations by direct integration. Solution of Lagrange's linear PDE. **Self study**: One dimensional heat and wave equations and solutions by the method of separable of variable **Video Link**: 1. http://nptel.ac.in/courses.php?disciplineID=111	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Make use of matrix theory for solving system of linear equations and compute eigenvalues and eigen vectors required for matrix diagonalization process.
CO2	Learn the notion of partial differentiation to calculate rates of change of multivariate functions and solve problems related to composite functions and Jacobians.
CO3	Understand the Three-Dimensional geometry basic, Equation of line in space-different forms, Angle between two line and studying the shortest distance .
CO4	Demonstrate various physical models through higher order differential equations and solve such linear ordinary differential equations.
CO5	Construct a variety of partial differential equations and solution by exact methods.

Reference Books	
1.	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 43rd Edition, 2013, .
2.	G. B. Gururajachar, Calculus and Linear Algebra, Academic Excellent Series Publicatior 2018-19
3.	Chandrashekar K. S, Engineering Mathematics-I, Sudha Publications, 2010.

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

Semester: V		
Technical Management and Entrepreneurship Theory - HSMC		
Course Code: MVJ21ME51		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Understand the fundamental concepts and principles of management and to help the students gain understanding of the functions and responsibilities of managers.
2	Understand the concepts of project management and collaborative project teams.
3	Understand the Traditional Project Management and launch and execute to TPM.
4	Understand the process of Workplace and Organizational vision
5	knowledge, with respect to concepts, principles and practical applications of technical innovations and Entrepreneurship

UNIT-I	
Management: Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches. Planning: Nature, importance and purpose of planning process Objectives - Types of plans - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans. Organizing and Staffing: Nature and purpose of organization Principles of organization - Types of organization - Departmental Committees, Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE Nature and importance of staffing--Process of Selection & Recruitment. Directing & controlling: Meaning and nature of directing - Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co - Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control. <u>Laboratory Sessions/ Experimental learning:</u> Case-Study Self Study For Leaders: A case-study type of self-study, with your leadership issue at the center, followed by discussion and debriefing are the closest thing to a real-life experience during the class. This helps student absorb concepts better and have practical discussions around their learning using the characters in the case study or their real-life situations. Application: Management of organizations, institutions and industries. Video link / Additional online information:	8 Hrs

• https://www.youtube.com/watch?v=d1jOwD-CTLI • https://www.youtube.com/watch?v=CXAzZRnJo2o • https://www.youtube.com/watch?v=nASV5I_WG3k	
UNIT-II	
Understanding the Project Management Landscape : Defining a Project, Defining a Program, Defining a Portfolio, Understanding the Scope Triangle, The Importance of Classifying Projects, Understanding the Fundamentals of Project Management, Challenges to Effective Project Management, Managing the Creeps, Introducing Project Management Life Cycles, Agile Project Management Approaches, Extreme Project Management Approach, Hybrid Project Management Approach, Choosing the Best-Fit PMLC Model, Definition of Strategic Project Management, The Business Environment: Business Climate, Market Opportunities , Enterprise Capacity, SWOT, Value Chain Analysis. Collaborative Project Team and PM Process Groups : The Complex Project Team, Project Executive, Core Team, Using the Co-Manager Model, Establishing Meaningful Client Involvement, The Challenges to Meaningful Client Involvement, Project Management Process Groups : Project Integration Management, Project Scope Management, Project Schedule Management, Project Cost Management, Project Quality Management. Project Resource Management, Project Communications Management, Project Risk Management, Project Procurement Management, Overview of the Process Groups, Mapping Knowledge Areas to Process Groups. Laboratory Sessions/ Experimental learning: • Role-Play Exercises : The best way to learn so-called "soft skills" is to practice them one-on-one opposite professional actors in customized, controlled and safe "role play" exercises. This ensures that learners get the experience they need to use those skills effectively in the real world. • Demonstration to students on the Organization behavioural skills will be given through case studies. • Applications-Organizing, Staffing and Coordinating in an organization Video link / Additional online information: • https://www.youtube.com/watch?v=dt_mMi5My14 • https://www.youtube.com/watch?v=BepKLu1mx4U	8 Hrs
UNIT-III	
Traditional Project Management (TPM): Using Tools, Templates, and Processes to Scope a Project, Managing Client Expectations, The Project Scoping Meeting, Project Scoping Meeting Deliverables. How to Plan a TPM Project: Using Tools, Templates, and Processes to Plan a Project, The Importance of Planning, Using Application Software Packages to Plan a Project, Planning and Conducting Joint Project Planning Sessions, Constructing the Project Network Diagram, Writing an Effective Project Proposal, Gaining Approval to Launch the Project. Launch and Execute a TPM Project: Using the Tools, Templates, and Processes to Launch a Project, Recruiting the Project Team, Developing a Team Deployment Strategy, Conducting the Project Kick-Off Meeting, Establishing Team Operating	8 Hrs

Rules, Managing Scope Changes, Managing Team Communications, Assigning Resources, Resource Leveling Strategies, Finalizing the Project Schedule, Writing Work Packages. Execute a TPM Project: Using Tools, Templates, and Processes to Monitor and Control, Establishing Your Progress Reporting System, Applying Graphical Reporting Tools, Managing the Scope Bank, Managing Project Status Meetings, Defining a Problem Escalation Strategy, Gaining Approval to Close the Project. Laboratory Sessions/ Experimental learning: • Demonstration to students on the Directing and Controlling will be given through case studies. • Buddy Programs And Peer Group Learning Experiences: Buddy programs and peer group learning experiences in the workplace, as well as open groups outside the workplace, are wonderful ways to practice learning in safe environments. Peers can share their personal experiences, and knowledge is exchanged and grows among peer group members. • Applications-Directing, Controlling the activities of an organization. Video link / Additional online information: • https://www.youtube.com/watch?v=vMJxNKpG0TA • https://www.youtube.com/watch?v=TNEYDBKmTNU	
UNIT-IV	
Understanding the Workplace: Defining Organizational Behaviour, Perception, Personality, and Emotions, Values, Attitudes, and Diversity in the Workplace, Groups and Teamwork: From Individual to Team Member, Stages of Group and Team Development, Creating Effective Teams, Interacting Effectively, The Communication Process, Barriers to Effective Communication, Organizational Communication, Power and Politics at the workplace, Conflict and Negotiation at workplace. **Sharing the Organizational Vision**: Organizational Culture: Definition of Organizational Culture, Creating and Sustaining an Organization's Culture, Changing Organizational Culture, Leadership: Leadership as Supervision, Inspirational Leadership, Contemporary Leadership Roles, Contemporary Issues in Leadership, Decision Making, Creativity, and Ethics: Individual and Group Decision Making, Creativity and Ethics in Organizational Decision Making. An introduction to organizational structure and change. Laboratory Sessions/ Experimental learning: • Stretch Assignments: Things such as leading a task force or leading a group on a topic where the person has no expertise, but the others are experts, can be invaluable. • Entrepreneurship development programs will be conducted to simulate and motivate the interests of students to become entrepreneurs.	8 Hrs

• Applications-Applying the concepts of entrepreneurship to become successful entrepreneurs and establish enterprises. Video link / Additional online information: • https://www.youtube.com/watch?v=lqC2cfwlILg&list=PLF1DBCAC25C2BC963&index=9 • https://www.youtube.com/watch?v=0wNuyNZIzrQ&list=PLF1DBCAC25C2BC963&index=26	
UNIT-V	
. **Introduction to Technological Innovation** : Innovation Systems, The Concept of Innovation Systems, Difference Between Innovation–Invention, Types and Characteristics of Innovation, Technological Innovation Management, Challenges in Technological Innovation Management, Basic Principles of Innovation Systems, Innovation Systems and Simulation Systems, System Dynamics as a Concept, Tool, and Process, Innovation Management Through Management of Knowledge and Education. Introduction to Intellectual property: Protecting your ideas. **Introduction to Technological Entrepreneurship**: Introduction, Definitions, Types of Entrepreneurship, Sustainable Entrepreneurship, Business Incubator, Technology Management and Transfer: Technology Technology Transfer, Technology Transfer Mechanisms, Technology Transfer Models, The Vicious Circle of Underdevelopment Versus Technology Transfer, Technology Transfer Obstacles, Success Factors for Technology Transfer, Cooperative Research and Development Agreements, Laboratory Sessions/ Experimental learning: • Students will be given an assignment for preparation of a project report for establishing a Small Scale Industry • Applications- Establishment and successful implementation of the concepts for running Industries. Video link / Additional online information: • https://www.youtube.com/watch?v=bXbOoobVN30 • https://www.youtube.com/watch?v=nITjNZb7_WM	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Discuss Decision making, Organizing, Staffing, Directing and Controlling.
CO2	Correlate concepts of Traditional Project Management and launch and execute TPM projects.
CO3	Plan and reframe the project management Landscape and Process Groups
CO4	Design and modify the organizational vision and workplace culture.
CO5	Plan and collaborate the concepts of Innovation and Entrepreneurship.

Reference Books	
1.	Principles of Management Tripathy and Reddy Tata McGraw Hill 3rd edition 2006.
2.	Organisational Behaviour by - Stephen Robbins - Pearson Education/PHI - 17th Edition, 2003
3.	Dynamics of Entrepreneurial Development & Management Vasant Desai - Himalaya Publishing House
4.	Entrepreneurship Development – Poornima. M. Charantimath Small Business Enterprises - Pearson Education - 2006 (2 & 4).

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	1	-	-	-	-	-	-	-	2	2	1	2
CO2	1	-	-	-	-	-	-	-	2	2	1	2
CO3	1	-	-	-	-	-	-	-	2	2	1	2
CO4	1	-	-	-	-	-	-	-	2	2	1	2
CO5	1	-	-	-	-	-	-	-	2	2	1	2

Semester: VII		
MECHANICAL VIBRATIONS (Theory)		
Course Code: MVJ21ME52		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Gain the knowledge of static and dynamic equilibrium conditions of mechanisms subjected forces and couple with and without friction.
2	Understand vibrations characteristics of single degree of freedom systems
3	Characterise the single degree freedom systems subjected to free and forced vibrations with and without damping.
4	Analyze the forced vibration with constant harmonic excitation.
5	Carryout the Numerical Calculations for Multi-degree freedom systems

UNIT-I	
Introduction: Definitions, Types of vibrations, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier theorem, Numerical on Fourier theorem, Components of vibratory systems. **Laboratory Sessions/ Experimental learning**: • Study of Numerical models and analysis of Fourier theorems and beats using MATLAB. **Applications**: Machine Tools, and Musical instruments, etc. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=yddIT1GnIfE 2. https://www.youtube.com/watch?v=KKel19UfNno 3. https://www.youtube.com/playlist?list=PL46AAEDA6ABAFCA78 https://www.youtube.com/watch?v=9_d8CQrCYUw	8 Hrs
UNIT-II	
Un damped free Vibrations (Single Degree of Freedom): Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems. **Laboratory Sessions/ Experimental learning**: • Study of Numerical models and analysis of vibratory systems using MATLAB. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=QIdIcCn6YGc 2. https://www.youtube.com/watch?v=4DF5qCxhxpM 3. https://www.youtube.com/watch?v=BkgzEdDlU78 4. https://www.youtube.com/watch?v=QIdIcCn6YGc	8 Hrs
UNIT-III	

Damped Free Vibrations: Introduction, Types of damping, and Vibrations with viscous damping, under damped, over-damped and critically-damped systems, logarithmic decrement. **Modal analysis and condition monitoring**: Signal analysis, dynamic testing of machines and structures, Experimental modal analysis, Machine condition monitoring and diagnosis. **Laboratory Sessions/ Experimental learning**: • Study of Numerical models and analysis of Damped vibratory systems using MATLAB. **Applications**: Bridges, Buildings, etc. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=YpiSZxDj7ws 2. https://www.youtube.com/watch?v=USa0VYAEzug 3. https://www.youtube.com/watch?v=YpiSZxDj7ws 4. https://www.youtube.com/watch?v=iNuV8Q0ZaPk	8 Hrs
UNIT-IV	
Forced Vibrations (Single Degree of Freedom): Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems. **Vibration Measuring Instruments & Whirling of Shafts**: Vibrometer and accelerometer. Whirling of shafts with and without air damping, discussion of speeds above and below critical speeds. **Laboratory Sessions/ Experimental learning**: • Study of Two Degree Freedom systems like vehicle suspension and dynamic vibration absorber. **Video link / Additional online information**: 1.https://www.youtube.com/watch?v=LbVL5O_bG9w 2. https://www.youtube.com/watch?v=4h5NOWTCVWM 3. https://www.youtube.com/watch?v=ETG6krVhN8w 4. https://nptel.ac.in/courses/112/103/112103111/	8 Hrs
UNIT-V	
Numerical Methods For Multi Degree Freedom Systems: Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonality of principal modes, method of matrix iteration - Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method. **Laboratory Sessions/ Experimental learning**: • Study of vibration analysis of real time application problems. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=TydULVPaFek 2. https://www.youtube.com/watch?v=M8bjJQFYMHU 3. https://nptel.ac.in/content/storage2/courses/112101096/download/lecture-29.pdf 4. https://www.youtube.com/watch?v=kT1c0iyFZmM	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.
CO2	Determine equation of motion, natural frequency, damping factor, logarithmic decrement of damped free vibration (SDOF) systems.
CO3	Determine the natural frequency, force and motion transmissibility of single degree freedom systems.
CO4	Determine equation of motion of rotating and reciprocating unbalance systems, magnification factor, and transmissibility of forced vibration (SDOF) systems.
CO5	Determine the equation of motion and degrees of freedom of multi-degree freedom system.

Reference Books	
10.	Leonanrd Meirovitch, 'Elements of Vibrations Analysis', TMH, Special Indian edition, 2007, ISBN-81-7700-047-0.
11.	S.Graham Kelly, 'Mechanical Vibrations', Schaum's outline series, TMH, Special Indian Edition, 2007, ISBN-14-09780070616790.
3.	S.S. Rao, 'Mechanical Vibrations', Pearson Education Inc, 6th Edition, 2017. ISBN9780134361307.
4.	Mechanical Vibrations, J. B. K. Das , Dr. P. L. Srinivasa Murthy, Sapna Publishers, ISBN-13: 9788128003714

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	-	-	-	-	1
CO2	3	2	2	2	2	-	1	-	-	-	-	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: V		
Fluid Mechanics & Machinery (Theory and Practice)		
Course Code: MVJ21ME53		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, vapour 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
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, orificemeters, 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
UNIT-III	
Fluid kinematics: Introduction, flow types. Equation of continuity for one dimensional flow, circulation and vorticity, Stream line, path line and streak lines and stream tube. Stream function and velocity potential function, differences and relation between them. Condition for irrotational flow, flow net, source and sink, doublet and vortex flow. **Dimensional Analysis**: Similitude and modelling – Dimensionless numbers **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.	08
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	08

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. **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.	
UNIT-V	
Hydraulic Turbines: Classification of turbines, Impulse and reaction turbines, Pelton wheel, Francis 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
LABORATORY EXPERIMENTS	
1. Determination of coefficient of friction of flow in a pipe. 2. Determination of minor losses in flow through pipes. 3. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades. 4. Determination of coefficient of discharge of various flow measuring devices. 5. Performance studies on Pelton, Francis, and Kaplan wheel turbines. 6. Performance of Single and Multistage Centrifugal Pump. 7. Performance test on Reciprocating Pump. 8. Performance test on a two stage Reciprocating Air Compressor. 9. Performance test on an Air Blower. **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 text book 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 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):

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 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.

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: V		
DESIGN OF MACHINE ELEMENTS (Theory and Practice)		
Course Code: MVJ21ME54		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	To explain the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity.
2	To understand and interpret different failure modes and application of appropriate criteria for design of machine elements.
3	Develop the capability to design elements like shafts, couplings and springs, welded joints, screwed joints.
4	To learn transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue
5	To produce assembly and working drawings of various mechanical systems involving machine elements like clutches and brakes

UNIT-I	
Introduction and Review: Review of engineering materials and their properties and manufacturing processes; use of codes and standards, selection of preferred sizes. Review of axial, bending, shear and torsion loading on machine components, combined loading, two- and three dimensional stresses, principal stresses, stress tensors, Mohr's circles. Video link / Additional online information: https://nptel.ac.in/courses/112105125/ https://nptel.ac.in/content/storage2/courses/112105125/pdf/Module-3_lesson-4.pdf https://nptel.ac.in/course.html https://nptel.ac.in/courses/111/104/111104095/	8 Hrs
UNIT-II	
Design for static strength: Factor of safety and service factor. Failure mode: definition and types. , Failure of brittle and ductile materials; even and uneven materials; Theories of failure: maximum normal stress theory, maximum shear stress theory, distortion energy theory, strain energy theory, Columba –Mohr theory and modified Mohr's theory. Stress concentration, stress concentration factor **Impact Strength**: Introduction, Impact stresses due to axial, bending and torsion loads. **Fatigue loading**: Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit. Laboratory Sessions/ Experimental learning: 1. Impact load: Experiment on impact loading.	8 Hrs

2. Fatigue: Demonstration with model. Applications: 1. Study the effect of different loads under design considerations. 2. Failure analysis of different materials. Video link / Additional online information: https://nptel.ac.in/courses/112105125/ https://nptel.ac.in/content/storage2/courses/112105125/pdf/Module-3_lesson-4.pdf https://nptel.ac.in/course.html https://nptel.ac.in/courses/111/104/111104095/	
UNIT-III	
Riveted joints: Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints, riveted brackets, Discussion on engineering applications. Welded joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints, Discussion on engineering applications. Threaded Fasteners: Stresses in threaded fasteners, effect of initial tension, design of threaded fasteners under static, dynamic and impact loads, design of eccentrically loaded bolted joints, Discussion on engineering applications. Laboratory Sessions/ Experimental learning: 1. Riveting: To do a tank by riveting. 2. Bolts: Loading and testing bolts. 3. Model on mounting and lifting mechanism. Applications: 1. Design of rivets on requirement view. 2. Study of various stresses in bolts design and design considerations. 3. Comparative study of hydraulic jack and screw jack. Video link / Additional online information: https://nptel.ac.in/courses/112105125/ http://www.nptelvideos.in/2012/12/design-of-machine-elements.html https://www.yumpu.com/en/document/view/11310280/design-of-eccentrically-loaded-bolted-riveted-joints-nptel https://nptel.ac.in/courses/112/105/112105124/	Hrs
UNIT-IV	
Spur Gears: Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear. Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.	Hrs

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear. **Worm Gears**: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives. **Applications**: Automobiles, Engines and Machineries **Video link/Additional online information: MOOC and Open courseware**: https://www.youtube.com/watch?v=AS0zQhMfJUw&list=PLSGws_74K01_e499POG3gczxcnlJEHMWE https://www.youtube.com/watch?v=i788-2pq1HA,https://www.youtube.com/watch?v=9XYeur-iVAs https://www.youtube.com/watch?v=oiBU7yxkpzc,https://www.youtube.com/watch?v=0rnTh6c19HM https://www.youtube.com/watch?v=a5A4LeqPtyg https://www.youtube.com/watch?v=L7i_QDehseg https://www.youtube.com/watch?v=gj2szHk0OCU https://www.youtube.com/watch?v=K5_ivdkRXp0	
UNIT-V	
Design of Clutches and Brakes: Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories. Design of band brakes, block brakes and internal expanding brakes **Lubrication and Bearings**: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. **Antifriction bearings**: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship, Discussion on engineering applications. **Video link/Additional online information: MOOC and Open courseware**: https://www.youtube.com/watch?v=gOuLq2haqLY,https://www.youtube.com/watch?v=wCu9W9xNwtI https://www.youtube.com/watch?v=pqF-aBtTBnY,https://www.youtube.com/watch?v=bMg_j5_AGMg https://www.youtube.com/watch?v=g5n8OqS1Fow,https://www.youtube.com/watch?v=wCu9W9xNwtI https://www.youtube.com/watch?v=SOgoejxzF8c,https://www.youtube.com/watch?v=8Jr44ybyS7U https://www.youtube.com/watch?v=devo3kdSPQY,https://www.youtube.com/watch?v=rOT4O-lwzu8 https://www.youtube.com/watch?v=98DXe3uKwfc,https://www.youtube.com/watch?v=6c4deRAhqcA	Hrs

https://www.youtube.com/watch?v=grfLkzjyc-o,https://www.youtube.com/watch?v=TsXQsw8EVgA https://www.youtube.com/watch?v=gxFRlkZMcJY,https://www.youtube.com/watch?v=VwgBSQ5tF3Y https://www.youtube.com/watch?v=wpretUMnW9g,https://www.youtube.com/watch?v=tP8nzvnqrPY	

LABORATORY EXPERIMENTS

1. Experimental studies of Single Degree of Freedom Vibrating systems.
2. Experiment on Governors – Porter/Proell/Hartnell to find the equilibrium speed, sensitiveness, power and effort.
3. Experiment on the balancing of rotating masses.
4. Experiment on rotating shafts to find the critical speed.
5. Experiment on Photo-elastic materials for the determination of the fringe constant using.
   a) Circular disc subjected to diametral compression.
   b) Pure bending specimen.
6. Determination of stress concentration using Photo-elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook
7. Experiment on Journal bearing to find the pressure distribution.
8. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain gauges
9. Determination of stresses in Curved beam using strain gauge.
10. Write codes in MATLAB/PYTHON to design a machine element.
11. Demonstration of Design and Analysis of a Welded Joint using appropriate modeling and analysis softwares.

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply codes and standards in the design of machine elements and select an element based on the Manufacturer's catalogue.
CO2	Analyze the performance and failure modes of mechanical components subjected to combined loading and fatigue loading using the concepts of theories of failure.
CO3	Demonstrate the application of engineering design tools to the design of machine components like shafts, springs, couplings, fasteners, welded and riveted joints, brakes and clutches
CO4	Design different types of gears and simple gear boxes for relevant applications.
CO5	Apply design concepts of hydrodynamic bearings for different applications and select Anti friction bearings for different applications using the manufacturers, catalogue.

Reference Books	
1.	Shigley's Mechanical Engineering Design Richard G. Budynas,and J. Keith Nisbett McGraw-Hill Education 10th Edition, 2015
2.	Design of Machine Elements V. B. Bhandari Tata Mcgraw Hill 4th Ed 2016.

3.	Machine Design- an integrated approach Robert L. Norton Pearson Education 2nd edition
4.	Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

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 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):

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 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.

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

Semester: V		
COMPUTER INTEGRATED MANUFACTURING (Theory)		
Course Code: MVJ21ME551		CIE Marks:100
Credits: L: T:P:S: 3:1:0:0		SEE Marks: 100
Hours: 40L+26T		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
2	The students will get the knowledge of high-quality production, the manufacturing and assembly line balancing and computerized manufacturing planning system.
3	To expose the students to CNC Machine Tools, CNC part programming
4	To impart the knowledge of computer aided quality control and shop floor control will help the students to compete with the present technology.
5	To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.

UNIT-I	
Computer Integrated Manufacturing System & High-Volume Production System: Introduction, Production concepts, Mathematical Models, Production economics, Costs in manufacturing, Break even analysis, Unit cost of production, Cost of MLT and WIP. Automated flow lines, work part Transport, Transfer Mechanism and Buffer Storage.	8 Hrs
UNIT-II	
Analysis of Automated Flow line and Line Balancing: Analysis of Transfer Lines without storage and with storage, Partial Automation, Manual Assembly Lines, Methods of Line balancing, Computerized Line Balancing. Automated Material Handling System, Automated guided vehicle system.	8 Hrs
UNIT-III	
Computerized Manufacturing Planning System and Flexible Manufacturing Systems: Computer Aided Process Planning: retrieval types, Generative type, Material Requirement Planning, Fundamental concepts of MRP, Inputs to MRP, Capacity Planning. Group technology. Flexible Manufacturing Systems, types of FMS, FMS components.	8 Hrs
UNIT-IV	
CNC Machining Centers: Introduction to CNC, elements of CNC, CNC machining centers, part programming, fundamental steps involved in development of part programming for milling and turning. Programming with canned cycles. Cutter radius compensations. **Shop Floor Control & Computer Aided Quality Control**: Factory, Data Collection System, Automatic identification system. Inspection methods, Non-Contact inspection methods, Co-ordinate measuring machine	8 Hrs
UNIT-V	
Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation,	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts.
CO2	Explain the basics of automated manufacturing industries through mathematical models and analyse different types of automated flow lines.
CO3	Analyse the automated flow lines to reduce down time and enhance productivity.
CO4	Explain the use of different computer applications in Shop Floor Control & computer aided quality control, and able to prepare part programs for simple jobs on CNC machine tools.
CO5	Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

Reference Books	
	Mikell P Groover, "*Automation, Production Systems and Computer-Integrated Manufacturing*", 4th Edition, 2015, Pearson Learning. ISBN-10 9789332572492
	P N Rao "*CAD / CAM Principles and Applications*", 3rd Edition, 2015, Tata McGraw-Hill. ISBN-10 9780070681934
3.	P. Radhakrishnan, "*CAD/CAM/CIM*" 3rd edition, New Age International Publishers, New Delhi. ISBN-10 8122439802
4.	Arshdeep Bahga and Vijay Madisetti, "*Internet of Things: A Hands-on Approach*", (Universities Press) ISBN-10 8173719543
Web links and Video Lectures (e-Resources): https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec12.mp4 https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec13.mp4 https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec14.mp4 https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec49.mp4 https://nptel.ac.in/content/storage2/112/104/112104288/MP4/mod01lec05.mp4 https://nptel.ac.in/content/storage2/112/104/112104288/MP4/mod01lec04.mp4 https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec48.mp4	

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	1											
CO2	1		2	2			1			2	2	
CO3	1							2	2	2	1	
CO4	1	2				2						2

Semester: V		
Industrial Internet of Things (Theory) – Professional Elective I		
Course Code: MVJ21ME552		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Understand the evolution of Industry 4.0 and the Internet of things
2	Understand the Industrial Internet and IIOT Architecture
3	Understand the designing of Industrial Internet and examining the access network for IIoT.
4	Understand the Emerging Hardware Technologies for IoT Data Processing and Architecting IoT Cloud and Machine Learning.
5	Understand the Systems Development for the Industrial IoT and Cyber Physical

UNIT-I	
Introducing Industry 4.0: Defining Industry 4.0, Four Main Characteristics of Industry 4.0, The Value Chain, Creating a Value Chain, Industry 4.0 Design Principles, Building Blocks of Industry 4.0, Industry 4.0 Design Principles, Building Blocks of Industry 4.0. Smart Factories: Introducing and need for Smart Factory, Digital Transformation, Transforming Operational Processes, Transforming Business Models, Increase Operational Efficiency, Adopt Smart Architectures and Technologies. Introduction to IoT – IoT Fundamentals: Definitions, Architectures, Challenges, and Promises : Internet of Things Terms and Acronyms, Impact and benefits of IoT, Architectures and Reference Models of IoT, Architectures and Reference Models of IoT, IoT Frameworks and Platforms, IoT Applications in Vertical Markets, IoT Business Implications and Opportunities, The Smart "Things" in IoT : Definition and Architecture of Smart Things, Engineering IoT Networks, The Simplified ISO/OSI Reference Model and IoT, IoT Network Technologies and Standards. Laboratory Sessions/ Experimental learning: • Demonstration of IoT in Data Management and Security. Applications: IoT for Industrial Automation. NPTEL/Additional Videos Link: https://www.youtube.com/watch?v=AQdLQV6vhbk	8Hrs
UNIT-II	
Introduction to the Industrial Internet, Catalysts and Precursors of the IIoT, Industrial Internet Use-Cases, The Technical and Business Innovators of the Industrial Internet, Network Virtualization, The Cloud and Fog, Big Data and Analytics, M2M Learning and Artificial Intelligence, Augmented Reality and Virtual Reality, People versus Automation, People versus Automation.	8 Hrs

Industrial Internet of Things (IIoT): Principles, Processes and Protocols, IIoT Reference Architecture : The IIC Industrial Internet Reference Architecture, Industrial Internet Architecture Framework (IIAF), Three Tier Topology, Key System Characteristics, Data Management, IIoT-Business Models, Industrial IoT- Layers. M2M AREA NETWORK PHYSICAL LAYERS, Power line Communication for M2M Applications. An introduction to ANSI C12 Suite, DLMS/COSEM and 6LoWPAN and RPL. Laboratory Sessions/ Experimental learning: • Demonstration of Application of IIoT in a production facility. Applications: Airbus: Factory of the Future NPTEL/Additional Videos Link: https://www.youtube.com/watch?v=Qs7bs2g7Usc https://www.youtube.com/watch?v=9Wh4PUN-viE	
UNIT-III	
Designing Industrial Internet Systems: The Concept of the IIoT, The Proximity Network, WSN Edge Node, Legacy Industrial Protocols, Legacy Industrial Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols, And Industrial Gateways. Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management. Examining the Access Network Technology and Protocols : The Access Network, Access Networks Connecting Remote Edge Networks, Examining the Middleware Transport Protocols, Middleware Software Patterns, Software Design Concepts, API (Application Programming Interface), Middleware Industrial Internet of Things Platforms. IIoT WAN Technologies and Protocols: IIoT Device Low-Power WAN Optimized Technologies for M2M, Millimeter Radio, Securing the Industrial Internet, Security in Manufacturing, PLCs and DCS. Laboratory Sessions/ Experimental learning: • Demonstration of the some basic exercises related to sensors. Applications: ABB: Smart robotics NPTEL/Additional Videos Link: https://www.youtube.com/watch?v=wgWRLu8p90M Experiential Learning: (Experiments which can be conducted on the concepts of contents) • Demonstration of network data transfer and protocols of various telecom companies. Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=XMAVAXj1WmQ	8Hrs
UNIT-IV	
Architecting IoT Cloud and Machine Learning: Fundamentals of Cloud Computing, Device Management Layer, Data Ingestion Layer, Data Processing	

Layer, Data Processing Layer, Application Layer, Data Visualization and Reporting Layer, Orchestration Layer, Virtualization, Scaling. Fundamental of Machine Learning: Regression Analysis, Feature Selection, Artificial Neural Networks, Clustering, Introduction to Big Data, Big Data Management and Computing Platforms. Introduction to Distributed Ledger Technology and IoT. Emerging Hardware Technologies for IoT Data Processing: Challenges for Data Processing in the Era of IoT, Recent Innovations for Bandwidth and Energy, Near-Memory Processing, In Situ Processing for IoT Devices, In Situ Data Clustering for IoT Servers, IoT Cyber Security: Cyber Security Controls for IoT Systems, Securing the IoT Edge, Interoperability in Smart Automation of Cyber Physical Systems, Artificial Intelligence and Data Analytics for Manufacturing, Cyber Physical Production Control. Laboratory Sessions/ Experimental learning: • Demonstration of functioning of different IoT tools Applications: IoT for Smart Cities and Smart Vehicles NPTEL/Additional Video Links: https://www.youtube.com/watch?v=wgWRLu8p90M Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=G3z27UaiBWg	8Hrs
UNIT-V	
Systems Development for the Industrial IoT: Challenges from Industry R&D, Internet of Measurement Things: Toward an Architectural Framework for the Calibration Industry, Architecture Modeling of Industrial IoT Systems Using Data Distribution Service UML Profile, Industrial IoT Projects Based on Automation Pyramid: Constraints and Minimum Requirements, Blockchain Mechanisms Security-Enabler for Industrial IoT Applications, Visible Light Communications in Industrial Internet of Things (IIoT), Implementation of Industrial Internet of Things in the Renewable Energy Sector. Internet of Things Applications and Use Cases in the Era of Industry 4.0. Industrial Internet of Things and Cyber Manufacturing Systems: An Application Map for Industrial Cyber-Physical Systems, Cyber-Physical Systems Engineering for Manufacturing, Model-Based Engineering of Supervisory Controllers for Cyber-Physical Systems, Evaluation Model for Assessment of Cyber-Physical Production Systems, CPS-Based Manufacturing with Semantic Object Memories and Service Orchestration for Industrie 4.0, Applications, Integration of a Knowledge Database and Machine Vision Within a Robot-Based CPS, Introduction to Cyber-Physical System Intelligence.	8Hrs

Laboratory Sessions/ Experimental learning: Case Studies on the application of IIoT in Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies : Milk Processing and Packaging Industries, Manufacturing Industries Applications: Smart Factories, Smart Products and Smart Services NPTEL/Additional Video Links: https://www.youtube.com/watch?v=gq0VWSXvG0s	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand general concepts of Internet of Things (IoT) (Understand)
CO2	Recognize various devices, sensors and applications (Knowledge)
CO3	Apply design concept to IoT solutions (Apply)
CO4	Analyse and Evaluate design issues in IoT applications (Analyse and Evaluate).
CO5	Create IoT solutions using sensors, actuators and Devices (Create).

Reference Books	
	The Internet of Things in the Industrial Sector, Mahmood, Zaigham (Ed.), Springer Publication. ISBN-13 978-3030248918
	Industrial Internet of Things: Cyber manufacturing System, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer Publication). ISBN:9783319425597, 3319425595
3.	Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Wiley Publications.
4.	Arsheep Bahga, Vijay Madisetti, Internet Of Things: A Hands-On Approach Paperback – Universities Press Publication, January 2015 Edition. ISBN-13 978-8173719547

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

Semester: V		
Supply Chain Management		
Course Code: MVJ21ME553		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to

1	To acquaint with key drivers of supply chain performance and their inter-relationships with strategy
2	To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
3	To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.
4	To study the various methods of demand forecasting and the related implementation issues. The contribution of information technology in facilitating the availability of these data is also discussed.
5	To study the Innovative supply chain strategies that enhance supply chain performance are highlighted and an introduction to SAP

UNIT-I	
The Role of Supply Chain Management in Economy and Organization, Supply Chain Strategy and Performance Measures, Customer Service and Cost Trade-offs, Supply Chain Performance Measures, Linking Supply Chain and Business Performance, Enhancing Supply Chain Performance. Outsourcing: Make Versus Buy The Strategic Approach, Identifying Core Processes, Market Versus Hierarchy, The Make-Versus-Buy Continuum. Supply Chain Drivers and Metrics: Drivers of Supply Chain Performance, Framework for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Obstacles to Achieving Fit, Competitive and Supply Chain Strategies, Achieving Strategic Fit, Expanding Strategic Scope. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) • https://www.youtube.com/watch?v=IMPbKVb8y8s (Inside Amazon's Smart Warehouse) • https://www.youtube.com/watch?v=8nKPC-WmLjU (Amazon Fulfillment Center Tour with AWS) • https://www.youtube.com/watch?v=6EDCnhbUpgE (Logistics of the Future)	8 Hrs
UNIT-II	
Managing Material Flow in Supply Chains : Inventory Management, Introduction, Types of Inventory. Inventory-related Costs, Ordering Costs,	8 Hrs

Inventory-carrying Costs, Stockout Costs, Managing Cycle Stock, Cycle Stock Inventory Model, Managing Safety Stock, Capturing Uncertainty, Impact of Service Level on Safety Stock, Managing Seasonal Stock, Planning for Seasonal Demand. Transportation: Introduction, Drivers of Transportation Decisions, And Modes of Transportation: Choices and Their Performance, Measures, Devising a Strategy for Transportation, Vehicle Scheduling Transportation Costs in E-Retailing. Network Design and Operations: Facility Location: Introduction, Network Operations Planning, Network Design Problem, Network Design and Operations Models: Extensions, Data for Network Design, Strategic Role of Units in the Network, Location of Service Systems Experiential Learning: (Experiments which can be conducted on the concepts of contents) •Study of Supply Chain Challenges for the Indian FMCG Sector • Video Links/Any other special information(Papers): (For additional study on the concepts of contents) • •https://www.youtube.com/watch?v=L24q9kl6z3s (Improve Material Flow and Value Chain Using Process Flow Insights) • •https://www.youtube.com/watch?v=yZC4neLax5o (Walmart Supply Chain) • •https://www.youtube.com/watch?v=VdFx2R6diMk (Retail Digital Supply Chains: Facing an omni channel customer-driven landscape)	
UNIT-III	
Managing Information Flow in Supply Chains: Demand Forecasting: The Role of Forecasting, Qualitative Forecasting Methods, Quantitative Methods. Information Technology in Supply Chain, Management. Introduction Enabling Supply Chain Management Through Information Technology, IT in Supply Chain Transaction Execution, IT in Supply Chain Collaboration and Coordination, IT in Supply Chain Decision Support, IT in Supply Chain Measurement and Reporting, Strategic Management Framework for IT Adoption in Supply Chain Management, Supply Chain Management Application Marketplace, Future Trends. Experiential Learning: (Experiments which can be conducted on the concepts of contents) •Impact of the Internet on Sourcing Strategy •Video Links/Any other special information(Papers): (For additional study on the concepts of contents) •https://www.youtube.com/watch?v=6EDCnhbUpgE	8 Hrs
UNIT-IV	
Supply Chain Innovations: Supply Chain Integration: Introduction, Internal Integration, External Integration, Building Partnership and Trust in a Supply Chain Supply Chain External Integration: Industry-level Initiatives.	8 Hrs

Supply Chain Restructuring: Introduction, Supply Chain Mapping, Supply Chain Process Restructuring, Postpone the Point of Differentiation, Changing the Shape of the Value-addition Curve, Advance the Customer Ordering Point: Move from MTS to CTO Supply Chain. Experiential Learning: (Experiments which can be conducted on the concepts of contents) •Incorporating Uncertainty in Network Design •Transportation Strategies Followed by Retail Firms Video Links/Any other special information(Papers): (For additional study on the concepts of contents) •https://www.youtube.com/watch?v=_wa0NCX-1kA	
UNIT-V	
Supply Chain Contracts: Incentive Conflicts in Supply Chains, Types of Supply Chain Contracts Effectiveness of Supply Chain Mechanisms, An introduction to Agile Supply Chains, Sustainable Supply Chain Management: Green Supply Chain Management. Pricing and Revenue Management: Pricing Revenue Management for Multiple Customer Segments, Pricing Under Capacity Constraint for Multiple Segments. Introduction to SAP, SAP Material Management, Procurement process, Organization structure, Enterprise structure, Master data management, purchase Info record, source list, procurement cycle, purchase requisition, request for quotation, purchase order, inventory management, invoice verification, service management, transaction code. Experiential Learning: (Experiments which can be conducted on the concepts of contents) •Hands on experience in SAP Software with Student edition Video Links/Any other special information(Papers): (For additional study on the concepts of contents) •https://www.youtube.com/watch?v=K-TWZwcybLo	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the Supply Chain Management and a Strategic View of Supply Chains
CO2	Plan the Managing Material Flow in Supply Chains and transportation
CO3	Develop the Managing Information Flow in Supply Chains
CO4	Plan and develop upply Chain Innovations and restructuring
CO5	Connect and correlate Supply Chain contracts and functioning of SAP software

Reference Books	
	Supply Chain Management : Text and Cases by Janat Shah ; Second Edition, 2016 Pearson India Education Services Pvt. Ltd, ISBN 978-93-325-4820-6, eISBN 978-93-530-6252-1

	Supply Chain Management by Sunil Chopra and Peter Meindl Pearson India Education Services Pvt. Ltd, ISBN:9780133800203, 0133800202
3.	Logistics and Supply Chain Management by MARTIN CHRISTOPHER, Pearson India Education Services Pvt. Ltd, ISBN:9781292083797, 1292083794
4.	Global Logistics and Supply Chain Management John Mangan, Chandra Lalwani, Agustina Calatayud · 2020 Pearson India Education Services Pvt. Ltd. ISBN-13978-1119702993

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

Semester: V		
Smart Materials and Structures (Theory)		
Course Code: MVJ21ME554		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 latest developments regarding smart materials and their use in structures.
2	Introduce smart materials, piezoelectric materials structures and its characteristics.
3	Elucidate the importance of smart fluids and fiber optics for applications in smart structures
4	Elucidate the concept of Signal Processing, Drive and Control Techniques.
5	Elucidate the concepts of MEMS and Microfabrication.

UNIT-I	
Overview of Smart Materials, Structures and Products Technologies: Smart Structures, Smart materials (Physical Properties), Piezoelectric Materials, Elecrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials, Magnetorheological Fluids, Electrorheological Fluids, Shape Memory Materials. **Smart Sensor, Actuator and Transducer Technologies**: Smart Sensors, Accelerometers, Force Sensors, Load Cells, Torque Sensors, Pressure Sensors, Impact Hammers.	8 Hrs
UNIT-II	
Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products: Case studies incorporating design, analysis, manufacturing and application issues involved in integrating smart materials and devices with signal processing and control capabilities to engineering smart structures and products; Emphasis on structures, automation and precision manufacturing equipment, automotives, consumer products, sporting products, computer and telecommunications products, as well as medical and dental tools and equipment.	8 Hrs
UNIT-III	
Electro rheological and Magneto rheological Fluids: 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). **Fibre Optics**: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements.	8 Hrs
UNIT-IV	
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	8 Hrs

methods; Structural dynamics and Identification techniques; Passive, Semi - active and Active control; Feedback and feed forward/control strategies. **Data Acquisition and Processing** – Signal Processing and Control for Smart Structures – Sensors as Geometrical Processors – Signal Processing – Control System – Linear and Non-Linear.	
UNIT-V	
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. ***Piezoelectric Sensing and Actuation***: Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Define the basic concepts of smart materials, structures and products technology
CO2	Understand Design, Analysis, Manufacturing and Applications of Engineering Smart Structures and Products
CO3	Understand the application of smart fluids.
CO4	Understand the principle of Measurement, Signal Processing, Drive and Control Techniques.
CO5	Get Knowledge on MEMS and MEMS fabrication techniques.

Reference Books	
1.	A.V.Srinivasan, "Smart Structures –Analysis and Design", Cambridge University Press, New York, 2001, (ISBN:0521650267).
2.	V. K. Varadan, K. J. Vinoy, S. Gopalakrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and Sons, England, 2006.
3.	M.V.Gandhi and B.S.Thompson, "Smart Materials and Structures" Chapmen & Hall, London, 1992 (ISBN:0412370107)
4.	Chang Liu "Foundation of MEMS", Pearson Education. (ISBN:9788131764756)
Web links and Video Lectures (e-Resources): 1. Prof. Nachiketa Tiwari, Prof. Bishakh Bhattacharya, Smart Material, Adaptive Structures and Intelligent Mechanical Systems - IITK, IIT Kanpur, https://nptel.ac.in/courses/112104173	

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: V		
ENVIRONMENTAL STUDIES		
Course Code: MVJ21ENV56		CIE Marks: 50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 15 L		SEE Duration: 2 Hrs.
Course Learning Objectives: The students will be able to		
1	Relate interdisciplinary approach to complex environmental problems using basic tools of the natural and social sciences including geo-systems, biology, chemistry, economics, political science and international processes	
2	Study drinking water quality standards and to illustrate qualitative analysis of water.	
3	Critically evaluate the science and policy ramifications of diverse energy portfolios on air and water quality, climate, weapons proliferation and societal stability.	

UNIT-I	
Introduction to environmental studies, Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development. **Ecosystems (Structure and Function):** Forest, Desert, Rivers, Ocean **Biodiversity:** Types, Hot spots; Threats and Conservation of biodiversity, Deforestation. Video link: https://nptel.ac.in/courses/127/106/127106004/	3 Hrs
UNIT-II	
Advances in Energy Systems (Merits, Demerits, Global Status and Applications): Hydrogen, Solar, Tidal and Wind. **Natural Resource Management (Concept and case-study):** Disaster Management, Sustainable Mining and Carbon Trading. Video link: https://nptel.ac.in/courses/121/106/121106014/	3 Hrs
UNIT-III	
Environmental Pollution: Surface and Ground Water Pollution, Noise pollution, Soil Pollution and Air Pollution. **Waste Management & Public Health Aspects:** Bio-medical Waste, Solid waste, Hazardous waste and E-waste. Video link:	3 Hrs

• https://nptel.ac.in/courses/122/106/122106030/ • https://nptel.ac.in/courses/105/103/105103205/ • https://nptel.ac.in/courses/120/108/120108005/ • https://nptel.ac.in/courses/105/105/105105160/	
UNIT-IV	
Global Environmental Concerns (Concept, policies, and case-studies): Global Warming, Climate Change, Acid Rain, Ozone Depletion and Fluoride problem in drinking water. Video link: • https://nptel.ac.in/courses/122/106/122106030/ • https://nptel.ac.in/courses/120108004/ • https://onlinecourses.nptel.ac.in/noc19_ge23/preview	3 Hrs
UNIT-V	
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems. Video link: • https://nptel.ac.in/courses/105/102/105102015/ • https://nptel.ac.in/courses/120/108/120108004/	3 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale.
CO2	Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
CO3	Demonstrate ecology knowledge of a complex relationship between biotic and Abiotic components.
CO4	Apply their ecological knowledge to illustrate and graph a problem
CO5	Describe the realities that managers face when dealing with complex issues.

Reference Books	
1.	Principals of Environmental Science and Engineering, Raman Siva kumar, Cengage learning, Singapur, 2nd Edition, 2005.
2.	Environmental Science – working with the Earth G.Tyler Miller Jr. Thomson Brooks /Cole, 11th Edition, 2006
3.	Textbook of Environmental and Ecology, Pratiba Singh, Anoop Singh & Piyush Malaviya , ACME Learning Pvt. Ltd. New Delhi, 1st Edition.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

CIE for 50 marks, executed by way of tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 40 marks and assignment is evaluated for 10 marks. The three tests are conducted for 40 marks each and the average of all the tests are calculated for 40. The marks for the assignments are 10 (2 assignments for 5 marks each). The marks obtained in test and assignment are added and report CIE for 50 marks.

Semester End Examination (SEE):

SEE for 50 marks, executed by means of an examination. The Question paper contains objective type questions for 100 marks covering the entire syllabus having same complexity in terms of COs and Bloom's taxonomy level.

Total marks: 50+50=100

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

Semester: V		
RESEARCH METHODOLOGY AND IPR		
Course Code:	MVJ21RMI57	CIE Marks:50
Credits: L:T:P:S:	1:2:0:0	SEE Marks: 50
Hours:	30	SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	To give an overview of the research methodology and explain the technique of defining a research problem and explain the basic ethics in research.	
2	To develop a suitable outline for research studies through various sources of information from literature review and data collection.	
3	To develop an understanding of the results and on analysis of the work carried.	
4	To Demonstrate enhanced Scientific writing skills.	
5	To Develop an Understanding on Various Intellectual Property Rights and importance of filing patents.	

UNIT-I	
Research Methodology: Introduction, Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem. *Ethics in Engineering Research:* Ethics in Engineering Research Practice, Types of Research Misconduct, Ethical Issues Related to Authorship.	6 Hrs
UNIT-II	
Research Writing and Journal Publication Skills: Understanding the importance of quality research papers, Differences between conference papers, journal articles, and other academic publications, criteria for selecting a journal, understanding impact factors and journal rankings. place of the literature review in research, how to review the literature, structure of a research paper, effective use of figures and tables, preparing a cover letter and author contributions, Responding to reviewers' comments. Attributions and Citations: Giving Credit Wherever Due, Citations: Functions and Attributes, Impact of Title and Keywords on Citations, Knowledge Flow through Citation, Citing Datasets, Styles for Citations, Tools for citation management, Acknowledgments and Attributions,	6 Hrs

What Should Be Acknowledged, Acknowledgments in, Books Dissertations, Dedication or Acknowledgments.	
UNIT-III	
Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. ***Results and Analysis:*** Importance and scientific methodology in recording results, importance of negative results, different ways of recording, industrial requirement, artifacts versus true results, types of analysis (analytical, objective, subjective), outcome as new idea, hypothesis, concept, theory, model etc.	6 Hrs
UNIT-IV	
Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.	6 Hrs
UNIT-V	
Introduction to Intellectual Property Rights: Meaning of property, Origin, Nature, Meaning of Intellectual Property Rights. Kinds of Intellectual property rights—Copy Right, Patent, Trademark, Trade Secret and trade dress, Design, Layout Design, Geographical Indication, Plant Varieties and Traditional Knowledge. Patents: Trips Definition, Patentable and Non-Patentable inventions, Legal requirements for patents. Patent application process: Prior art search, Drafting of a patent, Filing of a patent, Patent document: specification and claims, Granting of patent, Management of IP, Commercialization of IP – Assignment, licensing and infringement.	6 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	formulate the research problem and follow research ethics.
CO2	carry to carrying out a Literature survey for the topic identified

CO3	Analyse the research and interpret the outcomes of the research.
CO4	Enhance their technical writing skills
CO5	Understand the importance of Patenting, Licensing and technology transfer.

Text Books	
1.	C.R. Kothari, Research Methodology, Methods and Techniques, 2nd Revised edition, New Age International Publishers, 2015
2.	Neeraj Pandey and Khushdeep Dharni, Intellectual Property Rights, PHI Learning Pvt Ltd, 2014

Reference Books	
1.	Geoffrey Marczyk, David De Matteo, David Festinger (2005) Essentials of Research Design and Methodology, John Wiley & Sons, Inc.
2.	Carol Ellison (2010) McGraw-Hill's Concise Guide to Writing Research Papers, McGraw-Hill
3.	Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, Ess Publications. 2nd volume.
4.	Wadehra, B.L. (2000). Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing

Assessment Details (both CIE and SEE)

· The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

· The student has to obtain a minimum of 40% of maximum marks in CIE and a minimum of 40% of maximum marks in SEE.

· Semester End Exam (SEE) is conducted for 50 marks (2 hours duration).

· Based on this grading will be awarded.

· The student has to score a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

· Three Unit Tests each of 30 Marks (30 MCQ's) (duration 01 hour)

1. First test at the end of 5th week of the semester.

2. Second test at the end of the 10th week of the semester.

3. Third test at the end of the 15th week of the semester.

· Report Writing /Presentation/ Assignment to attain the COs and POs for 20 Marks, (Students can decide the topic for Mini Project and start doing literature survey, report of literature survey can be considered for assignments) At the end of the 13th week of the semester

· The average of three tests and report writing/presentation/Assignment summing to 50 marks

Semester End Examination:

· Theory SEE will be conducted by College as per the scheduled timetable, with common question paper for the subject

· SEE paper will be set for 50 questions of each of 01 marks. The pattern of the question paper is MCQ. The time allotted for SEE is 02 hours

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

High-3, Medium-2, Low-1

Semester: V		
UNIVERSAL HUMAN VALUES		
Course Code: MVJ21UHV58		CIE Marks: 50
Credits: L:T:P: 2:0:0		SEE Marks: 50
Hours: 30 L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2	Facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3	Highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

UNIT-I	
Introduction to Value Education: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education), Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity – the Basic Human Aspirations, Happiness and Prosperity – Current Scenario, Method to Fulfill the Basic Human Aspirations. **Practical Sessions**: (1) Sharing about Oneself (2) Exploring Human Consciousness (3) Exploring Natural Acceptance Video link: • https://www.youtube.com/watch?v=85XCw8SU084 • https://www.youtube.com/watch?v=E1STJoXCXUU&list=PLWDeKF97v9SP_Kt6jqzA3p Z3yA7g_OAQz • https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw	6 Hrs
UNIT-II	
Harmony in the Human Being: Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to ensure self-regulation and Health. **Practical Sessions**: (4) Exploring the difference of Needs of Self and Body (5)	6 Hrs

Exploring Sources of Imagination in the Self (6) Exploring Harmony of Self with the Body Video link: • https://www.youtube.com/watch?v=GpuZo495F24 • https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw	
UNIT-III	
Harmony in the Family and Society: Harmony in the Family – the Basic Unit of Human Interaction, 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Other Feelings, Justice in Human-to-Human Relationship, Understanding Harmony in the Society, Vision for the Universal Human Order. **Practical Sessions**: (7) Exploring the Feeling of Trust (8) Exploring the Feeling of Respect (9) Exploring Systems to fulfill Human Goal Video link: • https://www.youtube.com/watch?v=F2KVW4WNnS • https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw	6 Hrs
UNIT-IV	
Harmony in the Nature/Existence: Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfillment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence. **Practical Sessions**: (10) Exploring the Four Orders of Nature (11) Exploring Co-existence in Existence Video link: • https://www.youtube.com/watch?v=1HR-QB2mCF0 • https://www.youtube.com/watch?v=lfN8q0xUSpw • https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw	6 Hrs
UNIT-V	
Implications of the Holistic Understanding – a Look at Professional Ethics: Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics, Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession **Practical Sessions**: (12) Exploring Ethical Human Conduct (13) Exploring Humanistic Models in Education (14) Exploring Steps of Transition towards Universal Human Order Video link: • https://www.youtube.com/watch?v=BikdYub6RY0	6 Hrs

• https://www.youtube.com/channel/UCQxWr5QB_eZUnwxSwxXEkQw	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explore themselves, get comfortable with each other and with the teacher
CO2	Enlist their desires and the desires are not vague.
CO3	Restate that the natural acceptance (intention) is always for living in harmony, only competence is lacking
CO4	Differentiate between the characteristics and activities of different orders and study the mutual fulfillment among them
CO5	Present sustainable solutions to the problems in society and nature

Reference Books	
1.	AICTE SIP UHV-I Teaching Material, https://fdp-si.aicte india.org/ AicteSipUHV _download.php
2.	A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-1
3.	Teachers' Manual for A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2
4.	Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Continuous Internal Evaluation (CIE):
CIE for 50 marks 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):
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.
Total marks: 50+50=100

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

Semester: VI		
OPERATIONS RESEARCH (Theory)		
Course Code: MVJ21ME61		CIE Marks: 50
Credits: L:T:P: 2:2:0		SEE Marks: 50
Hours: 20 L+20 T		SEE Duration: 03
Course Learning Objectives: The students will be able to		
1	To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making	
2	To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and Machinery.	

UNIT-I	
Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as LPP. Solutions to LPP by graphical method (Two Variables). **Laboratory Sessions/ Experimental learning:** Case Studies for formulation of LLP to know the statistics for daily marketing of newspaper, banking sector, different firms. **Applications:** Formulation can be used in agriculture, financial sector, marketing. **Video link / Additional online information (related to module if any):** http://nptel.ac.in/courses/111107128/ https://nptel.ac.in/courses/111/107/111107128/ https://nptel.ac.in/courses/110/104/110104063/ https://onlinecourses.nptel.ac.in/noc21_mg43/preview	8 Hrs
UNIT-II	
Linear Programming Problems: Simplex method, Canonical and Standard form of LPP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method, Degeneracy in LPP. Solutions to L.P.P by Dual Simplex Method. **Laboratory Sessions/ Experimental learning:** Case Studies for formulation of LLP to utilize minimum resources available to achieve the target for different sectors like supply chain management, marketing. **Applications:** LPP can be used in defense, industries sectors and hospitals. Video link / Additional online information (related to module if any): http://nptel.ac.in/courses/112106134/ https://nptel.ac.in/courses/111/107/111107128/ https://nptel.ac.in/courses/110/104/110104063/ https://onlinecourses.nptel.ac.in/noc21_mg43/preview	8 Hrs
UNIT-III	
Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in	8 Hrs

Transportation problem by Modified Distribution (MODI) method, application of transportation problem. **Assignment Problem:** Formulation, Solutions to assignment problems by Hungarian method, unbalanced, Maximization assignment problems, Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Numerical Problems. **Laboratory Sessions/ Experimental learning:** Case Studies for different transportation system to obtain best optimal distance to reach the target. **Applications:** These methods can be used in transportation of goods and any other services. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/111/107/111107128/ https://nptel.ac.in/courses/110/104/110104063/	
UNIT-IV	
Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, Numerical Problems. **Queuing Theory:** Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models. **Laboratory Sessions/ Experimental learning:** Building a different network activity for financial and marketing projects management. **Applications:** Network and Queuing methods can be adopted in completing various projects within the given deadline to earn the profit and minimize the loss. Video link / Additional online information (related to module if any): http://nptel.ac.in/courses/110106062/ https://nptel.ac.in/courses/111/107/111107128/ https://nptel.ac.in/courses/110/104/110104063/ https://onlinecourses.nptel.ac.in/noc21_mg43/preview	8 Hrs
UNIT-V	
Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Formulation of games. **Sequencing:** Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. **Laboratory Sessions/ Experimental learning:** Collecting the statistical data to develop the project using Game theory and Sequencing. **Applications:** These methods give the perfect results of any production of machines.	8 Hrs

Video link : http://nptel.ac.in/courses/112106131/ https://nptel.ac.in/courses/112/106/112106134/ https://nptel.ac.in/courses/111/107/111107128/ https://nptel.ac.in/courses/110/104/110104063/	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.
CO2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
CO3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
CO4	Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks. Solve waiting line problems for M/M/1 and M/M/K queuing models.
CO5	Solve problems on game theory for pure and mixed strategy under competitive environment. Determine minimum processing times for sequencing for different n jobs and m machines using Johnson's algorithm.

Reference Books	
1.	Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006
2.	Operations Research, Paneerselvan, PHI
3.	Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt. Ltd. 2016.
4.	Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi – 2007.

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 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):

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.

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

VI Semester		
Heat Transfer (Theory and Practice)		
Course Code: MVJ21ME62		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	Students will build a strong foundation in heat transfer basics of conduction, convection, and radiation modes, two dimensional steady and unsteady heat transfer	
2	Students will be able to work on governing equations and solution procedures for the three modes along with solution of practical problems using empirical correlations	
3	Students will be able to analyze and design of the heat exchangers.	
4	Students will be able to understand boiling and condensation heat transfe	

UNIT-I	
Introduction-Modes and mechanisms of heat transfer: Basic laws of heat transfer, General discussion about applications of heat transfer. Conduction Heat Transfer: Fourier rate equation, General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates. Simplification and forms of the field equation: steady, unsteady, and periodic heat transfer, Initial and boundary conditions. Experiential Learning: 1. Thermal conductivity experiment in HMT lab. 2. Write a code/program to estimate the intermediate temperatures in composite wall. Applications: Insulation of industrial pipelines. Video link / Additional online information: 1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785&index=1	8 Hrs
UNIT-II	
Lumped system approximation and Biot number, heat transfer through pin fins- Two-dimensional conduction, solutions for both steady and unsteady heat transfer-approximate solution to unsteady conduction heat transfer using Heissler charts. Experiential Learning: 1. Determination of Effectiveness on a Metallic fin. 2. Experiment on Transient Conduction Heat Transfer. Applications: CPU cooling, Transformer cooling and engine cooling in automobiles. Video link / Additional online information: 1. https://www.youtube.com/watch?v=QcTr0-QrSMY&list=PL5F4F46C1983C6785&index=2	8 Hrs
UNIT-III	
Heat convection, basic equations, boundary layers- Forced convection, external and internal flows- Natural convective heat transfer- Dimensionless parameters for forced and free convection heat transfer-Correlations for forced and free convection- Approximate solutions to laminar boundary layer equations (momentum and energy) for both internal and external flow- Estimating heat	8 Hrs

transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection. Experiential Learning: 1. Determination of Heat Transfer Coefficient in free Convection 2. Determination of Heat Transfer Coefficient in a Forced Convection Applications: Heat exchangers, Gas turbine and steam turbine cooling, Refrigeration and air conditioning. Video link / Additional online information: 1. https://www.youtube.com/watch?v=ACjR7MIFaFw&list=PL5F4F46C1983C6785&index=3	
UNIT-IV	
Interaction of radiation with materials, definitions of radiative properties, Stefan Boltzmann's law, black and gray body radiation, Calculation of radiation heat transfer between surfaces using radiative properties, view factors and the radiosity method Experiential Learning: 1. Determination of Emissivity of a Surface. 2. Determination of Stefan Boltzmann Constant Applications: Solar power applications, electrical bulbs, microwave oven. Video link / Additional online information: 1. https://www.youtube.com/watch?v=hjrHtAnW4Ac	8 Hrs
UNIT-V	
Types of heat exchangers, Analysis and design of heat exchangers using both LMTD and & NTU methods, Boiling and Condensation heat transfer, Pool boiling curve, Introduction mass transfer, Similarity between heat and mass transfer. Experiential Learning: 1. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers. 2. Experiments on Boiling of Liquid and Condensation of Vapour **Applications**: Boilers, condensers, radiators, nuclear reactor cooling. **Video link / Additional online information**: 1. https://www.youtube.com/watch?v=V8Fa-b6Yx0k	8 Hrs
LABORATORY EXPERIMENTS	
Any 12 experiments to be conducted 1. Determination of Thermal Conductivity of a Metal Rod. 2. Determination of Overall Heat Transfer Coefficient of a Composite wall. 3. Determination of Effectiveness on a Metallic fin. 4. Determination of Heat Transfer Coefficient in a free Convection on a 5. Determination of Heat Transfer Coefficient in a Forced Convention Flow through a Pipe. 6. Determination of Emissivity of a Surface.	

7. Determination of Steffan Boltzmann Constant.
8. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
9. Experiments on Boiling of Liquid and Condensation of Vapour.
10. Performance Test on a Vapour Compression Refrigeration.
11. Demonstration of Air Conditioner Trainer Kit.
12. Transient and Steady State heat transfer Analysis of plane slab and cylinder using numerical approach.

Course Outcomes: After completing the course, the students will be able to	
CO1	After completing the course, the students will be able to formulate and analyse a heat transfer problem involving any of the three modes of heat transfer.
CO2	The students will be able to estimate heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection.
CO3	The students will be able to calculate radiation heat transfer between surfaces using radiative properties.
CO4	The students will be able to design thermal device such as heat exchangers.
CO5	The students will be able to understand better the boiling and condensation phenomenon and study pool boiling curves.

Reference Books	
1.	Fundamentals of Heat and Mass Transfer, M. Thirumaleshwar, Pearson Education India, 2009
2.	Nag, P.K., "*Heat Transfer*", Tata McGraw Hill, New Delhi, 2002
3.	Yunus A. Cengel, "*Heat Transfer A Practical Approach*", Tata McGraw Hill, 2010
4.	Kothandaraman, C.P., "*Fundamentals of Heat and Mass Transfer*", New Age International, New Delhi, 1998.

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 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):

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

Semester: VI		
ENERGY CONVERSION TECHNOLOGY (Theory and Practice)		
Course Code: MVJ21ME63		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	Explain various types of Conventional & Non-conventional Energy Sources and their resources scenario in India.
2	Explain combustion phenomenon in SI and CI Engines also factors effecting combustion variations in these engines
3	Calculate mixture requirement and pollutants produced in internal combustion engines.
4	Students will be able to explain how solar radiation will be converted into Thermal Energy and working of Photovoltaic Cells.
5	Students will understand how the conversion of Biomass and wind energy in to an useful energy

UNIT-I	
Introduction: Energy sources, India's production, and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Waterpower, wind, biomass, ocean thermal, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative). **Laboratory Sessions/ Experimental learning**: Case Study on Different Energy Sources. Video links: 1.https://nptel.ac.in/courses/121/106/121106014/ 2.https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s 3.https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s 4.https://www.youtube.com/watch?v=EXcNXLv2W3A	Hrs: 8
UNIT-II	
Construction and Operation: Engine classification, Constructional details of four stroke spark ignition (SI) and compression ignition (CI) engines. Working principles. Comparison of SI and CI engines , theoretical and actual valve timing diagrams for engines. **Engine Cycles**: theoretical Otto, diesel and dual cycles, Fuel-air Cycles and Actual cycle, numericals.	Hrs: 8
UNIT-III	
Combustion in Compression Ignition Engines: Types of diesel combustion systems: Direct injection systems, indirect injection systems, comparison of different combustion systems, Analysis cylinder pressure data; combustion efficiency, DI engines, IDI engines, Fuel spray behaviour: Fuel injection, overall spray structure, atomization, spray penetration, droplet size distribution and spray evaporation, Ignition delay: definitions and discussion, fuel ignition quality, auto ignition fundamentals, physical properties affecting delay, effect of fuel properties	Hrs: 8
UNIT-IV	

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems. **Photovoltaic Conversion**: Description, principle of working and characteristics, applications. Study of solar power stations in India. Limitations of solar power. **Laboratory Sessions/ Experimental learning**: Case study for design of solar panel for domestic applications & Case study on solar charging station. **Video links**: 1. https://www.youtube.com/watch?v=mpHZWYpKDJg 2. https://www.youtube.com/watch?v=GzMuLpsRY-8 3. https://nptel.ac.in/courses/121/106/121106014/	Hrs: 8
UNIT-V	
Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, aerodynamic considerations of windmill design, numerical examples. **Energy from Biomass**: Photosynthesis, photosynthetic oxygen production, energy plantation, biogas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages. 1. https://nptel.ac.in/courses/121/106/121106014/ 2. https://www.youtube.com/watch?v=-f88zBS8jlg&t=2s 3. https://www.youtube.com/watch?v=sJQwJX-YysY	Hrs: 8
LABORATORY EXPERIMENTS	
1. Determination of Calorific value of fuel. 2. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Marten's (closed) / Cleveland's (Open Cup) Apparatus. 3. Determination of Viscosity of lubricating oil using Redwoods, Saybolt and Torsion Viscometers 4. Valve Timing Diagram of an I.C. Engine	

5. Performance Tests on Two stroke Petrol Engine, Four Stroke Petrol Engine, Four Stroke Diesel Engines with different loading.
6. Performance test on 4-Stroke VCR(Variable Compression Ratio) Petrol Engine test rig
7. Measurements of Exhaust Emissions of Petrol engine.
8. Measurements of Exhaust Emissions of Diesel engine.
9. Demonstration of measurements of P-θ, PV plots using IC Engine test rig.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand various types of Conventional and Non-conventional Energy Sources.
CO2	Explain combustion phenomenon in SI and CI Engines also factors effecting combustion variations in these engines
CO3	Calculate mixture requirement and pollutants produced in internal combustion engines.
CO4	Apply the knowledge of solar radiation for power generation and domestic applications.
CO5	Study and understand power generation from Wind Energy and Biomass.

Reference Books	
1.	Internal Combustion Engines, V. Ganesan Tata McGraw Hill 2007
2.	Internal Combustion Engines Ramalingam K. K. Sci-Tech Publications 2005
3.	Internal Combustion Engines Mathur and Sharma Dhanpat Rai and Sons 2002
4.	Solar energy, by Subhas P Sukhatme – Tata McGraw Hill, 2nd Edition, 1996

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 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):

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 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.

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	1											
CO2	1		2	2			1			2	2	
CO3	1							2	2	2	1	
CO4	1	2				2						2

Semester: VI		
AUTOMOTIVE ENGINEERING		
Course Code: MVJ21ME641		CIE Marks:100
Credits: L:T:P:S: 3:1:0:0		SEE Marks: 100
Hours: 40L+26T		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	The layout and arrangement of principal parts of an automobile
2	The working of transmission and brake systems
3	The operation and working of steering and suspension systems
4	To know the Injection system and its advancements
5	To know the automobile emissions and its effects on environment

UNIT-I	
ENGINE COMPONENTS AND IT'S PRINCIPLE PARTS: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, choice of materials for different engine components, engine positioning. Concept of HCCI engines, hybrid engines, twin spark engine, electric car. COOLING AND LUBRICATION: cooling requirements, types of cooling-thermosiphon system, forced circulation water cooling system, water pump, Radiator, thermostat valves. Significance of lubrication, splash and forced feed system.	08 Hrs
UNIT-II	
TRANSMISSION SYSTEMS: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive. BRAKES: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock & Numerical	08 Hrs
UNIT-III	
STEERING AND SUSPENSION SYSTEMS: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system. IGNITION SYSTEM: Battery Ignition system, Magneto Ignition system, electronic Ignition system	08 Hrs
UNIT-IV	
SUPERCHARGERS AND TURBOCHARGERS: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag. FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES: Conventional fuels, alternative fuels, normal and abnormal combustion, cetane and octane numbers, Fuel mixture requirements for SI engines, types of carburetors, C.D.&	08 Hrs

C.C. carburetors, multi point and single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System	
UNIT-V	
AUTOMOTIVE EMISSION CONTROL SYSTEMS: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, controlling crankcase emissions, controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air aspirator system, Catalytic converter. EMISSION STANDARDS: Euro I, II, III and IV norms, Bharat Stage II, III, IV norms. Motor Vehicle Act	08 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	To identify the different parts of an automobile and it's working
CO2	To understand the working of transmission and braking systems
CO3	To comprehend the working of steering and suspension systems
CO4	To learn various types of fuels and injection systems
CO5	To know the cause of automobile emissions, its effects on environment and methods to reduce the emissions.

Reference Books

1.	Automotive mechanics, William H Crouse & Donald L Anglin (10th Edition) Tata McGraw Hill Publishing Company Ltd., 2007.
2.	Automotive mechanics: Principles and Practices, Joseph Heitner, D Van Nostrand Company, Inc
3.	Fundamentals of Automobile Engineering, K.K.Ramalingam, Scitech Publications (India) Pvt. Ltd.
4.	Automobile Engineering, R. B. Gupta, SatyaPrakashan (4th Edition) 1984.

Web links and Video Lectures (e-Resources):

https://www.motorbiscuit.com/4-types-of-car-transmissions-and-how-they-work/
https://www.youtube.com/watch?v=zA_19bHxEYg&t=6s
https://www.motorbiscuit.com/4-types-of-car-transmissions-and-how-they-work/
https://www.youtube.com/watch?v=fTnAoYBKXFU
https://www.youtube.com/watch?v=1k2aFMjRd9M

https://www.youtube.com/watch?v=V83pI7WbSpM

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 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.

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

Semester: VI		
OPERATIONS MANAGEMENT (Theory)		
Course Code: MVJ21ME642		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03
Course Learning Objectives: The students will be able to		
1	This course will give details about various engineering management system in the production industry.	
2	To study the about optimistic utility of the available resources like material and time.	

UNIT-I	
Production and Operations Management: Introduction, Functions within business organizations, the operation management function, Classification of production systems, Productivity, factors affecting productivity, contemporary issues and development **Decision Making**: The decision process, characteristics of operations decisions, use of models, decision making environments, graphical linear programming, analysis and trade-offs.	8 Hrs
UNIT-II	
Forecasting: Steps in forecasting process, approaches to forecasting, forecasts based on judgment and opinion, analysis of time series data, accuracy and control of forecasts, choosing a forecasting technique, elements of a good forecast. **Capacity & Location Planning**: Importance of capacity decisions, defining and measuring capacity, determinants of effective capacity, determining capacity requirement, developing capacity alternatives, evaluating alternatives, need for location decisions, nature of locations decisions, general procedure for making locations decisions, evaluating locations decisions, facilities layout - need for layout decisions, types of processing.	8 Hrs
UNIT-III	
Aggregate Planning and Master Scheduling: Aggregate planning - Nature and scope of aggregate planning, strategies of aggregate planning, techniques for aggregate planning - graphical and charting techniques, mathematical techniques. The master production schedule, Master scheduling process, Master scheduling methods. **Inventory Management**: Types of Inventories, reasons for holding inventory, objectives of inventory control, requirements for effective inventory management - information, cost, priority system.	8 Hrs
UNIT-IV	
Material Requirement Planning (MRP): Dependent versus independent demand, an overview of MRP - MRP inputs and outputs, MRP processing, An overview of MRP-II and ERP capacity requirement planning, benefits and limitations of MRP. **Purchasing and Supply Chain Management (SCM)**: Introduction, Importance of purchasing and SCM, The procurement process, Concept of tenders, Approaches to SCM, Vendor development, Measures of purchasing and SCM, Make or buy decision, Types of buying, E-procurement.	8 Hrs

UNIT-V	
Introduction to Quality: The Meaning of Quality and Quality Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; Total Quality Management (quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement). **Methods And Philosophy of Statistical Process Control**: Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts, warning limits, Average Run Length-ARL).	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Students will be able to acquire the decision-making ability in the production industry
CO2	Students will be able to visualize the future industrial demand in terms of product
CO3	Students will be able to control the inventory based on forecasting the demand
CO4	Students will be able to order the material based on the requirement and use it optimistically
CO5	Students will learn the quality tool like various charts to use in the industry

Reference Books	
1.	**William J Stevenson, "Production and Operations Management",** 9th Ed., Tata McGraw Hill, **ISBN:9789355322647**
2.	**B Mahadevan "Operations Management-Theory and Practice",** Pearson Education, 2007. **ISBN:81-7758-564-9**
3.	**R.B.Chase, N.J.Aquilino, F. Roberts Jacob "Operations Management for Competitive Advantage"** McGraw Hill Companies Inc., Ninth Edition. **ISBN: 007126048X**
4.	**Everett E.Adams, Ronald J.Ebert, "Production & Operations Management",** Prentice Hall of India Publications, Fourth Edition.**ISBN:81-203-083**

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=DVEbZ_FNRg
2. https://www.youtube.com/watch?v=1AN_L_8-x84
3. https://www.youtube.com/watch?v=Ic_El2DkpjA
4. https://www.youtube.com/watch?v=VjSgga4E6VY
5. https://www.digimat.in/nptel/courses/video/110105095/L01.html
6. https://www.youtube.com/watch?v=E4OYh890IRE
7. https://www.youtube.com/watch?v=Z1zi7fMLmV4
8. https://www.youtube.com/watch?v=TbPUiJKyxqw

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 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):

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.

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

Semester: VI		
ENGINEERING ECONOMICS		
Course Code: MVJ21ME643		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Explain the importance of engineering economics, Law of demand and supply in engineering decision making.
2	Describe various interest rate factors and implement the same for economic decision making.
3	Discuss different component of costs, methods of cost estimation and different methods of computing depreciation.
4	Discuss taxation concepts-income, corporate taxes and financial functions.
5	Explain the importance of engineering economics, Law of demand and supply in engineering decision making.

UNIT-I	
Introduction: Engineering Decision-Makers, Engineering and Economics, Problem solving and Decision making, Intuition and Analysis, Tactics and Strategy. Engineering Economic Decision. Law of demand and supply, Law of returns, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Personal loans and EMI payment calculation with flexible interest rates, Exercises and Discussion.	08 Hrs
UNIT-II	
Present-Worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present-worth equivalence, Net Present worth, Assets with unequal lives, infinite lives, Future-worth comparison, Future-worth equivalence, Pay-back comparison, Exercises, Discussions and problems.	08 Hrs
UNIT-III	
Equivalent Annual-Worth Comparisons: Equivalent Annual-Worth Comparison methods, Situations for Equivalent Annual-Worth Comparisons, Consideration of asset life, Comparison of assets with equal and unequal lives, Use of shrinking fund method, Annuity contract for guaranteed income, Exercises, Problems.	08 Hrs
UNIT-IV	
Costing and Depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, sum of years method, sinking fund method, taxation concepts, personal income taxes and corporate taxes, Discussions, and problems.	08 Hrs

UNIT-V	
Introduction, Scope of Finance, Finance Functions: Statements of Financial Information: Introduction, Source of financial information, financial statements, Balance sheet, Profit and Loss account, relation between Balance sheet and Profit and Loss account. Simple Numerical. *Financial Ratio Analysis:* Introduction, Nature of ratio analysis, Liquidity ratios, Leverage ratios, Activity ratios, Profitability ratios, Evaluation of a firm's earning power. Comparative statements analysis. Simple Numerical.	08 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand engineering economics demand supply and its importance in economics decision making and problem solving.
CO2	Calculate present worth, annual worth and IRR for different alternatives in economic decision making.
CO3	Understand the procedure involved in estimation of cost for a simple component, product costing and depreciation, its methods.
CO4	Examine the different economic analysis methods for decision making.
CO5	Understand the procedure of financial statements and balance sheets.

Reference Books	
1.	Leland Blank & Anthony Tarquin, *"Basics of Engineering Economy"*, McGraw Hill Publication (India) Private Limited.
2.	R.Paneerselvam, *"Engineering Economics"*, PHI publication.
3.	N. M. Fraser and E. M. Jewkes, Engineering Economics: Financial Decision Making for Engineers, 5th edition, Pearson, Toronto, Ontario, 2013
4.	J. A. White, K. E. Case and D. B. Pratt, Principles of Engineering Economic Analysis, 5th edition, Hoboken, NJ, USA, 2010.

Web links and Video Lectures (e-Resources):

- http://nptel.ac.in/courses/112107209/
- https://youtu.be/WYbC1-TsGis
- https://onlinecourses.nptel.ac.in/noc20_mg53/
- https://youtu.be/OqHEseiXcbg
- https://nptel.ac.in/courses/110/106/110106135/
- http://nptel.ac.in/courses/105103023/

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 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.

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

Semester: VI		
Non-Conventional Energy Sources (Theory)		
Course Code: MVJ21ME644		CIE Marks:100
Credits: L:T:P:S: 3:1:0:0		SEE Marks: 100
Hours: 40T		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	Students will be able to understand various types and utilization of Non-conventional Energy Sources.
2	Students will gain the knowledge about the utilization and applications of solar energy.
3	Students will be able to explain how solar radiation will be converted into Thermal Energy and working of Photovoltaic Cells.
4	Students will understand how the Biomass (Natural Waste) is converted in useful energy and Geothermal Energy.
5	Students will gain the knowledge about the generation of power from Wind Energy, Ocean Thermal Energy Conversion and Tidal Energy.

UNIT-I	
Introduction: Energy sources, India's production, and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Waterpower, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative). **Laboratory Sessions/ Experimental learning**: Case Study on Different Energy Sources. **Applications**: Energy Sector **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/ **Video link**: https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s https://www.youtube.com/watch?v=EXcNXLv2W3A	08
UNIT-II	
Solar Radiation: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. **Solar Radiation Geometry**: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. Radiation Flux on a Tilted Surface. Solar radiation measurement devices. **Laboratory Sessions/ Experimental learning**: Analysis of solar radiation data in different places across the country. **Applications**: Solar Power Generation. **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/	08

Video link: https://www.youtube.com/watch?v=CRFpoZjeWa4 https://www.youtube.com/watch?v=E4S02rc9AvM https://www.youtube.com/watch?v=ur5muGY5Gy4	
UNIT-III	
Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems. **Photovoltaic Conversion**: Description, principle of working and characteristics, applications. Study of solar power stations in India. Limitations of solar power. **Laboratory Sessions/ Experimental learning**: Case study for design of solar panel for domestic applications & Case study on solar charging station. **Applications**: Solar power stations. **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/ **Video link**: https://www.youtube.com/watch?v=mpHZWYpKDJg https://www.youtube.com/watch?v=GzMuLpsRY-8	08
UNIT-IV	
Energy from Biomass: Photosynthesis, photosynthetic oxygen production, energy plantation, biogas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages. **Geothermal Energy Conversion**: Principle of working, types of geothermal station, geothermal plants in the world, scope of geothermal energy and challenges associated with geothermal energy conversion. **Laboratory Sessions/ Experimental learning**: Visit to Biomass Gas Production Plant. Case study on design of bio-gas plant for 1Mw. **Applications**: Production of Gas and Power Generation. **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/ **Video link**: https://www.youtube.com/watch?v=sJQwJX-YysY https://www.youtube.com/watch?v=JInatzTBiKA https://www.youtube.com/watch?v=adSkrlyd2rQ&t=1s	08
UNIT-V	
Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, aerodynamic considerations of windmill design, numerical examples. **Tidal Power**: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations.	08

Ocean Thermal Energy Conversion (OTEC): Principle of working, Rankine cycle, OTEC power stations in the world, limitations of OTEC. **Laboratory Sessions/ Experimental learning**: Assignments on making models of windmills. **Applications**: Power Generation and Low heat Applications. **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/ **Video link**: https://www.youtube.com/watch?v=-f88zBS8jlg&t=2s, https://www.youtube.com/watch?v=WZBiznycjns **https://www.youtube.com/watch?v=F2YsrxpQPwE**	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand various types and utilization of Non-conventional Energy Sources.
CO2	To understand the impact of solar collector geometry.
CO3	Apply the knowledge of solar radiation for power generation and domestic applications.
CO4	Understand the Biomass (Natural Waste) conversion to useful energy and principles of geothermal Energy.
CO5	Gain the knowledge about the generation of power from Wind Energy, Ocean Thermal Energy Conversion and Tidal Energy.

Reference Books	
1.	Non-Conventional Energy Sources by G.D Rai K, Khanna Publishers, 2003, ISBN : 9788174090737
1.	Renewable Energy Sources and Conversion Technology by N.K.Bansal, Manfred Kleeman & Mechael Meliss, Tata McGraw Hill, 2001. ISBN : 9780074600238
3.	Renewable Energy Resources, John W.Twidell Anthony D. Weir El, BG 2001. ISBN 13: 9780415584388
4.	Solar energy, by Subhas P Sukhatme – Tata McGraw Hill, 2nd Edition, 1996, ISBN : 9789352607112

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				2	3					2
CO3	2	1				2	3					2
CO4	2	1				2	3					2
CO5	2	1				2	3					2

Semester: VI		
Design Thinking, AI and ML for Mechanical Engineers (Theory)		
Course Code: MVJ21MEA66		CIE Marks:50
Credits: L:T:P: 1:0:0		SEE Marks: 50
Hours: 15L		SEE Duration: 2 Hrs

Course Learning Objectives: The students will be able to	
1	Explain Need, Want, Demand, Customer Value, Product and Service.
2	Explain Innovation, understand creativity, barriers to creativity, skills for creativity.
3	Explain the principles of design thinking and its approaches.
4	Identify the empathy, define phases in human centred design problems.
5	Understand the idea generation, prototype and testing in design thinking context

UNIT-I	
INTRODUCTION TO DESIGN THINKING: An insight into Engineering design, Design, Human centered Design, Design Thinking. Origin of Design thinking, importance of Design thinking, understanding Design thinking and its process models (Stanford Model, Double Diamond Model), application of Design thinking.	3 Hrs
UNIT-II	
EXPLORE, EMPATHIZE AND DEFINE: Human-Centred Design (HCD) process – Problem Space: Empathize, define; Solution Space: Ideate, Prototype and Test and Iterate. Role of Empathy in design thinking, methods and tools of empathy, understanding empathy tools. Explore define phase, state users' needs and problems using empathy methods.	3Hrs
UNIT-III	
IDEATION, PROTOTYPING AND TESTING: Ideation Phase, Ideation methods: Random Word Technique, SCAMPER, brain storming, Analogy, Biomimicry. PROTOTYPE AND TESTING: Prototyping: Role of prototyping in DT. Build to learn, Prototyping principles, and Approaches. Low Fidelity, models, High Fidelity Models. Models using different mediums. Rapid prototyping; user testing methods, Advantages and limitations of user Testing, Feedback, Design Iteration.	3 Hrs
UNIT-IV	
Introduction to AI for Mechanical Engineers: Basics of AI for Mechanical Engineers Applications of AI in Mechanical Engineering, Advanced search, Constraint satisfaction problems, Knowledge representation & reasoning, Non-standard logics, Uncertain and probabilistic reasoning. Case Studies on Application of AI in Smart Manufacturing.	3 Hrs
UNIT-V	
Conceptual introduction to Machine Learning for Mechanical Engineers: Introduction to Neural Networks, Supervised, Unsupervised, and Semi-Supervised Learning, Deep Learning, Reinforcement Learning, Linear	3 Hrs

Regression, Case Studies on Machine Learning for Industrial Robotics and Automation.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the Need, Want, Demand, Customer Value, Product and Service.
CO2	Understand the Innovation, creativity, barriers to creativity, and skills for creativity.
CO3	Able to identify the empathy, define phases in human centered design problems.
CO4	Able to identify the significance of AI for Mechanical Engineering Applications.
CO5	Apply the machine learning algorithms to find the solutions for a given mechanical engineering problem.

Reference Books	
1.	Innovation by Design, Thomas Lockwood, New Page Books, 2017.
2.	Change by design, Tim Brown, Harper Collins, Harper Collins, 2009
3.	The Design Thinking Playbook, Michael Lewrick, Wiley, 2019.
4.	Chandra S.S.V, Artificial Intelligence and Machine Learning, Prentice Hall India Learning Private Limited; Standard Edition, ISBN-13 : 978-8120349346.

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	-	-	-	-	1
CO2	3	2	2	2	2	-	1	-	-	-	-	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: VI		
Mini project (Theory and Practice)		
Course Code: MVJ21MEP67		CIE Marks:50
Credits: L: T:P:S: 0:0:4:0		SEE Marks:50
Hours: 3		SEE Duration:

Course Learning Objectives: The students will be able to	
1	To ensure graduates will be proficient in utilizing the fundamental knowledge of basic sciences, mathematics and Information Technology for the applications relevant to various streams of Engineering and Technology.
2	To enrich graduates with the core competencies necessary for applying knowledge of computers and telecommunications equipment to store, retrieve, transmit, manipulate and analyze data in the context of business enterprise.
3	To enable graduates to think logically, pursue lifelong learning and will have the capacity to understand technical issues related to computing systems and to design optimal solutions.
4	To enable graduates to develop hardware and software systems by understanding the importance of social, business and environmental needs in the human context.
5	To enable graduates to gain employment in organizations and establish themselves as professionals by applying their technical skills to solve real world problems and meet the diversified needs of industry, academia and research.

Sl. No	PHASES FOR PROJECT WORK
1	Introduction and Problem Definition
2	Summary of literature survey
3	Formulation of revised project objectives
4	Proposed Methodology and implementation
5	Results and discussion
6	Project report documentation
7	Oral presentation

Course outcomes:	
CO1	Perform literature review on par with international journal standards
CO2	Identify literature gap and define the problem.
CO3	Design experiments scientifically/perform numerical analysis/develop analytical models and interpret the results and apply advanced tools/techniques for solving the problem.
CO4	Compile the results, discuss the findings and draw the conclusions for the project.
CO5	Prepare quality document of project work.

Reference Books:	
1.	J. P. Holman, "*Experimental Methods For Engineers*", McGraw-Hill Companies, Eighth edition, 2012.
2.	Prasanna Chandra, "*Projects- Appraisal, Preparation, Budgeting and Implementation*", McGraw-Hill Companies, 1987.
Scheme of Examination:	

1.	Relevance of the topic: 10 marks
2.	Report: 20 marks
3.	Evaluation by Guide: 25 marks
4.	Presentation: 30 marks
5.	Viva – Voce: 15 marks

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

High-3, Medium-2, Low-1

Semester: VI		
SUMMER INTERNSHIP-II		
Course Code: MVJ21INT68		CIE Marks:50
Credits: 2		SEE Marks: 50
Hours:		SEE Duration: 3

Course Learning Objectives: The students will be able to	
1	Get an inside view of an industry and organization/company
2	Gain valuable skills and knowledge
3	Make professional connections and enhance student's network
4	Get experience in a field to allow the student to make a career transit
5	To build a record of work experience and construct a good relationship with the employers.

Guidelines
➢ Students have to undergo this training for a period of 6 weeks (minimum) during the vacation between even and odd semesters. ➢ Those students who are unable to complete during these periods will have to undergo the internship after VIII semester and VIII semester grade card will be issued only after the successful completion of internship by that student ➢ The department shall nominate a faculty as a mentor for a group of students to prepare and monitor the progress of the students ➢ The students shall report the progress of the internship to the mentor/guide at regular intervals and may seek his/her advice. ➢ After completion of Internship, students shall submit a report to the department with the approval of both internal and external guides/mentors. ➢ Evaluation of Internship shall be conducted during VIII semester by internal and external examiners for 100 marks. ➢ The external examiner shall be from the industry where the student carried out the internship. In case of non-availability of external examiner, the concerned head of the department shall appoint an external examiner from the nearby college or a senior faculty member from outside the department in consultation with respective BOE and approved by Principal ➢ The internship carries three credits. A student has to get a minimum of 40% marks for a pass. If the student fails to complete the same then internship has to be repeated in its entirely ➢ The breakup of marks for the evaluation of training is as in table.

Evaluation by the supervisor under whom the training was carried out	25 Marks
Evaluation by DSEC	
1. Relevance of the Field training/Industrial Internship	10 Marks
2. Report	25 Marks
3. Evaluation	40 Marks
Total	100
Course outcomes:	

CO1	To experience a 8 weeks' internship training, enabling the student for onsite visits, study projects and practical training.
CO2	To develop a skill for handling multiple situations, practical problems, analyzing teamwork and communication abilities
CO3	To integrate theory with practice and carry out performance objectives on strong work ethics, persistence, adaptability and critical
CO4	To analyze work environment and create solution to problems.
CO5	To build a record of work experience and construct a good relationship with the employers.

Reference Books:	
1	T1. Pamela Myers Kiser, "Human Services Internship: Getting the Most From Your Experience", Cengage Learning, 4th Edition, 2016. (ISBN13: 978-1305087347)

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

High-3, Medium-2, Low-1

Semester: VII		
FINITE ELEMENT METHODS (Theory and Practice)		
Course Code: MVJ21ME71		CIE Marks:50+50
Credits: L:T:P: 3:0:1		SEE Marks: 50 +50
Hours:40 L+ 26 P		SEE Duration: 03+03 Hours
Course Learning Objectives: The students will be able to		
1	To learn basic principles and methodologies of finite element analysis.	
2	To understand the theory and characteristics of finite elements used in analysis of complexed engineering problems.	
3	To introduce formulation of engineering problems into FEM by discretization process, polynomial, interpolation, application of boundary conditions, assembly of global arrays, solution of the resulting algebraic systems.	
4	To apply finite element solutions to structural, thermal, dynamic problems to develop the knowledge and skills needed to effectively evaluate finite element analysis.	
5	To learn basic principles and methodologies of finite element analysis.	

UNIT-I	
Pre-requisites: Mechanics of Materials, Engineering Mathematics. *Introduction to Finite Element Method:* General description of the finite element method, Steps involved in FEM, Engineering applications of finite element method. Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Convergence criteria. *Finite Element Formulation method:* Galerkin's method, Potential energy method, Rayleigh Ritz method, Convergence criteria, Discretisation process, Displacement method of finite element formulation. *Basic Procedures:* Force terms: Body force, Traction force and point loads, Equilibrium equations, Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions. Applications: Stress analysis in solids and automotive design. Video link / Additional online information: 1. https://www.youtube.com/watch?v=KR74TQesUoQ 2. https://www.youtube.com/watch?v=LCTp7H6Tb8w 3. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/lecture-notes/	8 Hrs
UNIT-II	
Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates, Linear interpolation polynomials in terms of local coordinates for 1D, 2D elements, Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant Strain Triangle (CST), Four-Nodded Tetrahedral Element, Eight-Nodded Hexahedral Element, Iso, Super and Sub parametric elements. *Numerical integration:* Gaussian quadrature: one point, two-point formulae, 2D integrals.	8 Hrs

Interpolation and Polynomial approximation: Interpolation – Linear Regression, Lagrange interpolation functions and approximation methods. **Applications**: Structural analysis of aircraft wing. **Video link / Additional online information:** 1. https://www.youtube.com/watch?v=pCSpBYfbYYA 2. https://nptel.ac.in/courses/112/104/112104115/ 3. https://www.youtube.com/watch?v=em1JdaEGXaQ 4. https://www.youtube.com/watch?v=JphRVN9Eezc	
UNIT-III	
Analysis of Bars: Stiffness matrix formulation for bar element, Solution for displacements, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach. Temperature effects. *Trusses:* Stiffness matrix formulation for truss element, load vector, Solution for truss members. *Torsion of Shafts:* Finite Element Analysis of shafts, determination of stress and twists in circular shafts. **Applications**: Structural analysis of a bridge. **Video link / Additional online information:** 1. https://www.youtube.com/watch?v=MldJ6WHCsvQ 2. https://www.youtube.com/watch?v=UsMyQ7yPHk8 3. https://nptel.ac.in/courses/112/104/112104193/ 4. https://www.youtube.com/watch?v=yfyElneBW98	8 Hrs
UNIT-IV	
Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins. *Fluid flow analysis:* Introduction to Computational Fluid Dynamics (CFD), Computational analysis of flow through uniform, tapered and stepped pipes, porous medium, channels and hydraulic networks. **Applications**: Structural analysis of an advertising roof sign subject to pressure loads from 120km/h winds. **Video link / Additional online information:** 1. https://youtu.be/l8t-7-pODN4?list=PLbMVogVj5nJRjnZA9oryBmDdUNe7lbnB0 2. http://www.nptelvideos.in/2012/11/finite-element-analysis.html 3. https://www.youtube.com/watch?v=9MddG4RqOqU	8 Hrs
UNIT-V	
Beams: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load. *Axis-Symmetric Solid Elements:* Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to point loads.	8 Hrs

Applications: Structural analysis of a structure subject to gyroscopic dynamic effects. **Video link / Additional online information:** 1. https://youtu.be/_iB21ry4tj0?list=PLA4CBD0C55B9C3878 2. http://www.nptelvideos.in/2012/12/introduction-to-finite-elementmethod.html 3. https://www.youtube.com/watch?v=6LrjKsg2iI0	

LABORATORY EXPERIMENTS

1. Study of a FEA package and modelling and stress analysis.
2. Analysis of Bars of constant cross section area, tapered cross section area and stepped bar
3. Analysis of Trusses – (Minimum 2 exercises of different types)
4. Analysis of Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc. (Minimum 6 exercises)
5. Stress analysis of a rectangular plate with a circular hole.
6. Demonstration of Static Structural analysis for different boundary conditions.
7. Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)
8. Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition b) Response of beam with fixed – fixed end conditions subjected to forcing function c) Response of Bar subjected to forcing functions.
9. Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.
10. Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
11. Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.

Any 10 experiments to be conducted

Course Outcomes: After completing the course, the students will be able to	
CO1	Recognize the importance of FEM and its concepts for real time applications.
CO2	Analyse different variational methods to solve the problem
CO3	Understand use of FEA in Structural and thermal problem
CO4	Learn how to do analysis and learn the various concepts and types of analysis
CO5	Learn finite element modelling techniques.

Reference Books	
1.	Rao, S. S., *"Finite Element Method In Engineering"*, 5th Edition, Pergaman Int. Library of Science, 2010.
2.	Logan, D. L., *"A First Course In The Finite Element Method"*, 6th Edition, Cengage Learning, 2016.
3.	Chandrupatla T. R., *"Finite Elements in Engineering"*, 2nd Edition, PHI, 2013.

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 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):

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 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.

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	1	1	1	2	1	-	-	-	-	1
CO2	3	2	2	2	2	-	1	-	-	-	-	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: VII		
NON-DESTRUCTIVE TESTING (Theory)		
Course Code: MVJ21ME721		CIE Marks: 50
Credits: L: T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	To provide a basic understanding with case studies on different surface NDE techniques and apply them for inspecting materials in accordance with industry specifications and standards.
2	Principles of various NDT techniques.
3	The equipment required for the NDT.
4	The procedure followed in NDT techniques.
5	Applications of NDT and recent trends in NDT.

UNIT-I	
VISUAL INSPECTION AND EDDY CURRENT TESTING: Scope and advantages of NDT, Comparison of NDT with DT, classifications of NDT Visual Inspection Equipment used for visual inspection - Magnifying Glass Magnifying Mirror, Microscope Borescope, endoscopes or endprobes Flexible Fiber Optic Borescope, Video Image scope. Eddy Current Testing- Principle, Advantages, Disadvantages, Factors Affecting Eddy Current Response - Material Conductivity Permeability - Frequency - Geometry-Proximity (Lift off) - Typical Applications, limitations, Types of Probes.	8 Hrs
UNIT-II	
LIQUID PENETRANT TESTING: Liquid penetration testing - Introduction, Principle, Equipment, Procedures, Characteristics of penetrants – developers – Evaluation - hazards Precautions, advantages, Limitations and applications.	8 Hrs
UNIT-III	
MAGNETIC PARTICLE TESTING: Principle of Magnetic Particle Testing-different methods to generate magnetic fields -Magnetic Particle Testing Equipment - Magnetic Particle Testing Procedures Method of De-Magnetization - Magnetic Particle Medium-Evaluation of Indications and Acceptance Standards - magnetic particle test-applications, advantages and limitations.	8 Hrs
UNIT-IV	
RADIOGRAPHIC TESTING: X-ray radiography principle, equipment & methodology – Type of Industrial Radiation sources and Application-Radiographic exposure, Factors and Technique - GAMA Ray and X-Ray Equipment-Radiographic Procedure - Radiograph Interpretation, Radiography Image Quality Indicators-Radiographic Techniques - Film Processing-Methods of Viewing Radiographs- Radiographic Testing Procedures for welds. Precautions against radiation hazards.	8 Hrs
UNIT-V	
ULTRASONIC TESTING:	8 Hrs

Introduction, Principle of operation Type of Ultrasonic Propagation- Ultrasonic probes. Types of Transducers - Ultrasonic Testing Techniques. Method for Evaluating Discontinuities - Ultrasonic Testing Procedures for different component - applications, advantages and limitations, Documentation, Applications in inspection of castings, forgings, Extruded steel parts, bars, pipes, rails and dimensions measurements.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the fundamental concepts of NDT & NDE and Explain the concept of Thermography and Eddy current testing.
CO2	Explain the concept of Liquid penetration testing.
CO3	Explain the concept of Magnetic Particle Testing.
CO4	Explain the concept of Radiography and inspect for in-service damage in the components.
CO5	Explain the concept of Ultrasonic Testing and Acoustic Emission.

Reference Books	
1.	J Prasad, C G K Nair, "Non-Destructive Testing and Evaluation of Materials", Tata McGraw Hill Education Private Limited
2.	American Metals Society, "Non-Destructive Examination and Quality Control", Metals Hand Book, Vol. 7, 9th Ed, Metals Park, OH, 1989.
3.	Bray, Don. E and Stanley, Roderic. K, "Nondestructive Evaluation: A Tool in Design, Manufacturing and Service. Revised", CRC Press New York, Edition 1997.
4.	P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press, 1st edition (2002).

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/noc/courses/noc16/SEM2/noc16-mm07/
- https://nptel.ac.in/courses/113106070
- https://archive.nptel.ac.in/courses/113/106/113106070/
- https://www.youtube.com/watch?v=oqMXbxk4RHI
- https://npti.gov.in/non-destructive-testing-welding-defects

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
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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: VII		
Mechatronic System Design (Theory)		
Course Code: MVJ21ME722		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	Gain knowledge of basics of Mechatronics system design and sensors
2	Understanding various techniques of Mechatronics system design for solving engineering problems.
3	Understanding Dynamic responses of systems and Fault detection techniques
4	Determination of optimization solutions, effective decision making, Convert the data in real time interfacing.
5	Understand real time mechatronic system design through case study

UNIT-I	
Introduction to mechatronics System Design: Mechatronics Definition, integrated design issues in Mechatronics, the Mechatronics design process, the key elements, Application of Mechatronics. Sensors in Mechatronics: sensors for motion and position measurement. Force and pressure sensors. Sensors for temperature measurements.	8 Hrs
UNIT-II	
Modeling and Simulation of Physical Elements: Operator notation and transfer functions, Block diagrams, manipulations and simulation, block diagram modeling- Direct method and analogy approach, Electrical systems, Mechanical systems (Rotational and Translational), electrical Mechanical Coupling, Fluid systems	8 Hrs
UNIT-III	
Dynamic responses of systems and Fault Finding. Modelling of dynamic systems, Terminology, first order systems and second order systems. Fault detection techniques, Parity and error coding checks, Common hardware faults. Microprocessor systems. Emulation and simulation.	8 Hrs
UNIT-IV	
Signal Conditioning and Real time Interfacing for Mechatronics systems: Introduction, elements of Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for data conversion, Data conversion process, Application software.	8 Hrs
UNIT-V	
Case Studies: Comprehensive and Data acquisition case studies, data acquisition and control case studies, Case studies of design and system level integration of any two Mechatronic systems.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Discuss about Mechatronics design process and select the sensor and Actuator for a Mechatronics application
CO2	Explain Modeling and Simulation of mechanical Elements, electrical Elements and fluid system the sensors in mechatronics systems and Fault detection techniques in Mechatronics.

CO3	Understand about the dynamic responses of system and fault finding.
CO4	Elucidate Signal conditional devices and real time interfacing for Mechatronics systems.

Reference Books	
1.	Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning Publishing Company, Vikas publishing house, 2001.
2.	A textbook of Mechatronics, R K Rajput, S Chand & Co. 2007.
3.	Bray, Don. E and Stanley, Roderic. K, "Nondestructive Evaluation: A Tool in Design, Manufacturing and Service. Revised", CRC Press New York, Edition 1997.
4.	P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press, 1st edition (2002).

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

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 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
CO2	3		2	2			1				2	1
CO3	2									2	1	2
CO4	3	2	1	2	1	2					2	2

Semester: VII		
Electric and Hybrid Vehicles Technology (Theory)		
Course Code: MVJ21ME723		CIE Marks: 50
Credits: L: T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Introduce the fundamental aspects of Autonomous Vehicles.
2	Gain Knowledge about the Sensing Technology and Algorithms applied in Autonomous vehicles.
3	Understand the Connectivity Aspects and the issues involved in driverless cars.

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 management strategies, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	8 Hrs

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): NOC:Fundamentals of Electric vehicles: Technology & Economics, IIT Madras Prof. Ashok Jhunjhunwala Prof. Prabhjot Kaur Prof. Kaushal Kumar Jha Prof. L Kannan 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: VII		
COMPUTATIONAL MECHANICS (Theory)		
Course Code: MVJ21ME724		CIE Marks: 50
Credits: L: T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.

Course Learning Objectives: The students will be able to	
1	Introduce the fundamental aspects of Autonomous Vehicles.
2	Gain Knowledge about the Sensing Technology and Algorithms applied in Autonomous vehicles.
3	Understand the Connectivity Aspects and the issues involved in driverless cars.

UNIT-I	
Introduction – origins of nonlinearity Mathematical Preliminaries -1: Tensors and tensor algebra Mathematical Preliminaries -2: Linearization and directional derivative, Tensor analysis	8 Hrs
UNIT-II	
Kinematics – 1: Deformation gradient, Polar decomposition, Area and volume change Kinematics – 2: Linearized kinematics, Material time derivative, Rate of deformation and spin tensor	8 Hrs
UNIT-III	
Kinetics – 1 : Cauchy stress tensor, Equilibrium equations, Principle of virtual work Kinetics – 2 : Work conjugacy, Different stress tensors, Stress rates	8 Hrs
UNIT-IV	
Hyperelasticity - 1: Lagrangian and Eulerian elasticity tensor Hyperelasticity - 2: Isotropic hyperelasticity, Compressible Neo-Hookean material	8 Hrs
UNIT-V	
Linearization : Linearization of internal virtual work, Linearization of external virtual work Discretization: Discretization of Linearized equilibrium equations – material and geometric tangent matrices Solution Procedure: Newton-Raphson procedure, Line search and Arc length method	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the concepts of computations mechanics for Multiphysics problems
CO2	Understand the tensors and tensor algebra and their significance.
CO3	Categorize non linearities in solid mechanics.
CO4	Summarize the concepts of hyper elasticity and their significance in continuum mechanics.

CO5	Discretise linearized equilibrium equations by material and geometric tangent matrices.

Reference Books	
1.	Applied Mechanics of Solids by A. F. Bower, CRC Press, Boca Raton, 2010. (Also accessible through authors website: http://solidmechanics.org/)
2.	Finite Element Procedures by K.-J. Bathe Prentice-Hall India, New Delhi, 1996.
3.	Applied Mechanics of Solids by A. F. Bower, CRC Press, Boca Raton, 2010. (Also accessible through authors website: http://solidmechanics.org/)
Web links and Video Lectures (e-Resources): 1. https://archive.nptel.ac.in/courses/112/103/112103296/	

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: VII		
Design of Experiments (Theory)		
Course Code: MVJ21ME731		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	Understand the significance of Design of Experiments in Research.
2	Know the concepts of optimization in their project work.
3	Get familiarized with the Multi variable unconstraint optimization
4	Gain knowledge on Multi variable constrain optimization
5	Elucidate the various stochastic methods for constrained optimization.

UNIT-I	
Introduction – Principles of optimization, Formulation of objective function, design constraints-classification of optimization problems. Single variable unconstraint optimization – Boundary phase method- Fibonacci search method- Golden section search method – Newton – Raphson method. **Laboratory Sessions/ Experiential learning**: • Demonstration of classical optimization techniques in open source software packages. **Applications**: Optimization of the set of experiments for practical conduction. **Video link**: https://www.youtube.com/watch?v=p5I_vRPyUc0	8 Hrs
UNIT-II	
Multi variable unconstraint optimization- classical method-Optimization with Equality and Inequality constraints Simplex search method– Conjugate gradient method – Variable-metric method. (Applications of these techniques in Design problems). **Laboratory Sessions/ Experiential learning**: • Developing a multi variable unconstrained model for optimization. **Applications**: Design of Experiments for optimization of the process parameters. **Video link**: https://www.youtube.com/watch?v=qzXPaWl-BzM	8 Hrs
UNIT-III	
Multi variable constraint optimization: Lagrange's multipliers - Kuhn-Tucker conditions – Penalty function method – Frank-Wolfe method– Generalized projection method. (Applications of these techniques in Design problems). **Laboratory Sessions/ Experiential learning**: • Developing a multi variable constrained model for optimization. **Applications**: DOE for the FMCG industry during its product development	8 Hrs

phase **Video link**: https://www.youtube.com/watch?v=niEtQin_D30	
UNIT-IV	
Multi objective optimization: Conjugate gradient method - reduced Conjugate gradient method– Newton – Raphson method (Applications of these techniques in Design problems) Integer Programming – Branch and bound method, Introduction to Geometric programming and Dynamic programming. **Laboratory Sessions/ Experiential learning**: • Studying the multi objective optimization techniques for dynamic programming. **Applications**: Multiple criteria decision making **Video link**: https://www.youtube.com/watch?v=Hm2LK4vJzRw	8 Hrs
UNIT-V	
Stochastic method: Genetic algorithms (GAs): working principle – difference between GAs and traditional methods – GAs for constrained optimization – Simulated annealing- Ant colony algorithm. **Laboratory Sessions/ Experiential learning**: Demonstration of the Genetic Algorithms in MATLAB/Open Source Software packages. **Applications**: Stochastic methods for process optimizations. **Video link**: https://www.youtube.com/watch?v=aprcWHKDaqw	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the importance of Design of Experiments for research.
CO2	Apply the optimization techniques in real time engineering problems.
CO3	Explain multivariate constraint optimization.
CO4	Explain multi objective optimization techniques for experiments.
CO5	Define the Principles of genetic algorithm for constrained optimization

Reference Books	
1.	Design and Analysis of Experiments, Douglas C. Montgomery, 5th Edition Wiley India Pvt. Ltd. 2007
2.	Quality Engineering using Robust Design, Madhav S. Phadke, Prentice Hall PTR, Englewood Cliffs, New Jersy 07632, 1989.
3.	Experiments Planning, analysis, and parameter Design optimization, C.F. Jeff Wu Michael Hamada, John Wiley Editions. 2002.
4.	Design and Analysis of Experiments (English, Paperback, Das, M. N. ,Giri, N.C.), Publisher: New Age International, Genre: Engineering, ISBN: 9789386418906, 9386418908, Edition: Third Edition, 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 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

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										2
CO2	3		2	2			1				2	1
CO3	2									2	1	2
CO4	3	2	1	2	1	2					2	2
CO5	2											1

Semester: VII		
NOISE,VIBRATION,HARSHNESS (Theory)		
Course Code: MVJ21ME732		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs.
Course Learning Objectives: The students will be able to		
1	Gain knowledge in basic of vibration and noise.	
2	Understanding the effect of noise on human comfort and environment.	
3	Knowing the methods of vibration and noise measurement.	

UNIT-I	
FUNDAMENTALS OF ACOUSTICS AND NOISE, VIBRATION Theory of Sound—Predictions and Measurement, Sound Sources, Sound Propagation in the Atmosphere, Sound Radiation from Structures and Their Response to Sound, General Introduction to Vibration, Vibration of Simple Discrete and Continuous Systems, Random Vibration, Response of Systems to Shock, Passive Damping	8 Hrs
UNIT-II	
EFFECTS OF NOISE, BLAST, VIBRATION, AND SHOCK ON PEOPLE General Introduction to Noise and Vibration Effects on People and Hearing Conservation, Sleep Disturbance due to Transportation Noise Exposure, Noise-Induced Annoyance, Effects of Infrasound, Low-Frequency Noise, and Ultrasound on People, Auditory Hazards of Impulse and Impact Noise, Effects of Intense Noise on People and Hearing Loss, Effects of Vibration on People, Effects of Mechanical Shock on People, Rating Measures, Descriptors, Criteria, and Procedures for Determining Human Response to Noise.	8 Hrs
UNIT-III	
TRANSPORTATION NOISE AND VIBRATION—SOURCES, PREDICTION, AND CONTROL Introduction to Transportation Noise and Vibration Sources, Internal Combustion Engine Noise Prediction and Control—Diesel, Exhaust and Intake Noise and Acoustical Design of Mufflers, Tire/Road Noise—Generation, Measurement, and Abatement, Aerodynamic Sound Sources in Vehicles—Prediction and Control, Transmission and Gearbox Noise and Vibration Prediction and Control, Brake Noise Prediction and Control.	8 Hrs
UNIT-IV	
INTERIOR TRANSPORTATION NOISE AND VIBRATION SOURCES - PREDICTION AND CONTROL Introduction to Interior Transportation Noise and Vibration Sources, Automobile, Bus, and Truck Interior Noise and Vibration Prediction and Control, Noise and Vibration in Off-Road Vehicle Interiors-Prediction and Control,	8 Hrs
UNIT-V	

NOISE AND VIBRATION TRANSDUCERS, ANALYSIS EQUIPMENT, SIGNAL PROCESSING, AND MEASURING TECHNIQUES General Introduction to Noise and Vibration Transducers, Measuring Equipment, Measurements, Signal Acquisition, and Processing, Acoustical Transducer Principles and Types of Microphones, Vibration Transducer Principles and Types of Vibration Transducers, Sound Level Meters, Noise Dosimeters, Analyzers and Signal Generators, Equipment for Data Acquisition, Noise and Vibration Measurements, Noise and Vibration Data Analysis, Calibration of Measurement Microphones, Calibration of Shock and Vibration Transducers, Metrology and Traceability of Vibration and Shock Measurements.	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand sources of noise and vibration.
CO2	Determine the effects of noise and vibrations on human health and building structures.
CO3	Recognize the different control techniques for noise and vibrations
CO4	Determine the measurement techniques of noise
CO5	Understand the vibration pertaining to an automobile.

Reference Books	
1.	Abdul Samad & Ranjeet Singh Rathore" Shyam Sunder Suthar, Y. B. Mathur, Noise Vibration and Harshness Paperback – 1 January 2011, ASIN : B07GXBKJCK Publisher : Neelkanth Publishers.
2.	Clarence W. de Silva , "Vibration Monitoring, Testing, and Instrumentation ",CRC Press, 2007
3.	David A.Bies and Colin H.Hansen "Engineering Noise Control: Theory and Practice "Spon Press, London, 2009.
4.	Allan G. Piersol ,Thomas L. Paez "Harris' Shock and Vibration Handbook", McGraw-Hill , New Delhi, 2010.

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	-	-	-	-	1
CO2	3	2	2	2	2	-	1	-	-	-	-	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: VII		
Theory of Plasticity (Theory)		
Course Code: MVJ21ME733		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	To understand the concepts of stresses, strains and stress-strain relationships, as well as Yield and failure criteria.
2	To provide the knowledge of various theoretical elements of plasticity and establish plasticity models for metallic structures.
3	To apply the principles of the theory of plasticity for large deformations in nonlinear analysis of structures.
4	To understand the concepts of stresses, strains and stress-strain relationships, as well as Yield and failure criteria.
5	To provide the knowledge of various theoretical elements of plasticity and establish plasticity models for metallic structures.

UNIT-I	
Introduction to the concept of plastic deformation-Role of microstructure and thermodynamics in plastic deformation - Constitutive responses: elastic, viscoelastic, plastic, visco plastic, anisotropy etc. Experiential Learning: (Experiments which can be conducted on the concepts of contents) The microstructure of the plastically deformed material can be seen using microscope in the material testing lab Video Links: https://www.youtube.com/watch?v=psbtzIts6Ks https://www.youtube.com/watch?v=lWr8fmUGXeE	8 Hrs
UNIT-II	
Physical overview of crystal plasticity, plasticity of granular media, plasticity in rubber-like materials, etc. (Rate independent plastic deformation) - Rate dependent and rate independent plasticity - Plastic strain, incremental strain, objective rates, and hardening variables - Yield criteria - Plastic work Experiential Learning: The variation in the hardness on any material can be studied using Brinell and rockwell hardness test in the material testing lab Video Links: https://www.youtube.com/watch?v=iV8XxRkW2NY https://www.youtube.com/watch?v=pZGv5MG3LBc	8 Hrs

UNIT-III	
(Drucker's postulate) - Maximum dissipation and normality rule (Associated flow rules) - Hardening rules (isotropic and kinematic) - Non-associated flow rules Experiential Learning: (Experiments which can be conducted on the concepts of contents) The heat dissipation of an material due to plastic deformation can be studied in Heat and Mass transfer lab using the experiment. Video Links: https://www.youtube.com/watch?v=-za4mAZkVgg https://www.youtube.com/watch?v=nHCXczzC28I	8 Hrs
UNIT-IV	
Axisymmetric problems in plasticity - Basic equations of plane strain and plane stress - Slip lines and their properties - Limit analysis and shakedown theorems (Plastic stability and waves) - Concept of plastic stability - Global stability criteria according to Hill - Elastoplastic column buckling - Local Stability criteria (localization, shear bands, ellipticity) Experiential Learning: (Experiments which can be conducted on the concepts of contents) Using ANSYS software the axisymmetric problem for the given type of element can be analysed in the computed aided modeling and analysis lab Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=dDl6k2kX7zs https://www.youtube.com/watch?v=NAqnB8I9nvU	8 Hrs
UNIT-V	
Introduction to dynamic plasticity - One-dimensional - Phase transformation and plasticity, strain gradient plasticity, dislocation plasticity, crystal plasticity. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Strain hardening of the material can be demonstrated to the students in material testing lab as well in foundry and forging lab Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=JwhEcrsM2QU https://www.youtube.com/watch?v=MIByupl3EY8	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Differentiate elastic and plastic behavior from stress-strain curves
CO2	Identify plastic yield criteria to establish constitutive modeling
CO3	Interpret material constants in mathematical formulation of constitutive relationship
CO4	Analyze boundary value problems with elasto-plastic prop
CO5	Examine the theoretical concepts and principles underlying elasticity and plasticity.

Reference Books	
1.	R. Hill, The Mathematical Theory of Plasticity, Oxford University Press, London, 2004.
2.	S. J. Hu, Z. Marciniak, J. L. Duncan, Mechanics of Sheet Metal Forming, Butterworth Heinemann, 2002.
3.	S. Singh, Theory of Elasticity, Khanna Publishers, New Delhi, 2000.

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	2	2	-	-	-	-	-	-	3	3
CO2	3	2	2	2	-	-	-	-	-	-	3	3
CO3	2	3	2	-	-	-	-	-	-	-	3	3
CO4	2	3	2	-	-	-	-	-	-	-	3	3
CO5	2	3	3	-	-	-	-	-	-	-	-	3

Semester: VII
SOLAR ENERGY (Theory)

Course Code: MVJ21ME734		CIE Marks:100
Credits: L:T:P:S: 2:2:0:0		SEE Marks: 100
Hours: 40L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	To be able to learn and understand the energy scenario of India & world with need of alternative energy sources
2	To be able to learn and understand solar radiation
3	To be able to analyze performance of liquid flat plate collectors and solar air heaters
4	To be able to learn and understand the concept and use of concentrating collectors
5	To be able to learn and understand various thermal energy storage systems

UNIT-I	
Energy Scenario & An Overview of Thermal Applications **Energy Scenario**: Introduction to production and reserves of commercial energy resources, Energy alternatives. **An Overview of Thermal Applications**: Devices for thermal collection and storage, Thermal applications like Solar water heating, air heating, space heating & cooling, agricultural & industrial process heat, distillation, furnace. Cooking, greenhouse, hydrogen production. **Experiential Learning**: Case study on Solar devices and report submission. **Video Links/Any other special information**: 1. https://www.youtube.com/watch?v=rnum4VH6sh0 2. https://www.youtube.com/watch?v=gEGPd5gi8aU 3. https://www.youtube.com/watch?v=YhGldo1Azcs 4. https://www.youtube.com/watch?v=XkpKsBIW7tI	Hrs: 8
UNIT-II	
Solar Radiation: Solar radiation outside the earth's atmosphere and at the earth's surface, Instruments for measuring solar radiation and sunshine, solar radiation data, solar radiation geometry, empirical relations for predicting the availability of solar radiation **Experiential Learning**: Analysis of solar radiation data in different places across the country. **Video Links/Any other special information**: 1. https://www.youtube.com/watch?v=zVUBDWGLDnE 2. https://www.youtube.com/watch?v=THR8u_tfq1Y 3. https://www.youtube.com/watch?v=g4zd9gFMaS0 4. https://www.youtube.com/watch?v=PPICpKYnJs0 5. https://www.youtube.com/watch?v=rnM1hXJf4WU	Hrs: 8
UNIT-III	
Liquid Flat Plate Collectors & Solar Heaters **Liquid Flat Plate Collectors**: Introduction, performance analysis, transmissivity, Overall loss coefficient and heat transfer correlations, Effects of various parameters on performance, Simple numerical examples **Solar Heaters**: Introduction, performance analysis of a conventional air heater, other types of air heaters. Simple numerical examples **Experiential learning**: Solar water heaters – Mini project	Hrs: 8

Video link / Additional online information: 5. https://www.youtube.com/watch?v=wvl0QAQCJyc 6. https://www.youtube.com/watch?v=UfoSAjW62vw 7. https://www.youtube.com/watch?v=XzCQN4zumTU https://www.youtube.com/watch?v=cgLj3u4TohU	
UNIT-IV	
Concentrating Collectors Introduction, Flat-plate collectors with plane reflectors, cylindrical and compound parabolic collectors, paraboloid dish collector, central receiver collector - no derivations. Experiential learning: Concentrating Collectors - Mini project Video link / Additional online information: 7. https://youtu.be/4-BI22Wx4Pc, 8. https://youtu.be/vt1_7f5l3hI, 9. https://youtu.be/NtoTpeWAAWc 10. https://youtu.be/N86Wi6npX5Y	Hrs: 8
UNIT-V	
Thermal Energy Storage Introduction, Solar energy storage systems, Solar Pond – Principle of operation and description of non-convective solar pond, extraction of thermal energy, applications of solar pond. Experiential learning: Case study on energy storage system and report submission Video link / Additional online information: 2. https://youtu.be/q6NLoo8k8DI 3. https://www.youtube.com/watch?v=LlhQCP0UFoo 4. https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-basics 5. https://www.youtube.com/watch?v=mvUZDP8Z0Pg	Hrs: 8

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the energy scenario and need of alternative energy sources
CO2	Understand concept of solar radiations, its geometry and measurement
CO3	Application of solar energy for liquid flat plate collector & air heaters
CO4	Understand the working of concentrating collectors
CO5	Study various solar energy storage devices and application of solar pond

Reference Books	
1.	Sukhatme S.P. Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi, Third Edition, 2012.
2.	Tiwari G.N, "Solar Energy – Fundamentals Design, Modelling and applications, Narosa Publishing House, New Delhi, 2002.
3.	John A. Duffie, William A. Beckman, Solar Energy: Thermal Processes, 4 th Edition, john Wiley and Sons, 2013
4.	Non-Conventional Energy Sources by G.D Rai K, Khanna Publishers, 2003

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	1											
CO2	1		2	2			1			2	2	
CO3	1							2	2	2	1	
CO4	1	2				2						2

Semester: VII		
COMPOSITE MATERIALS (Theory)		
Course Code: MVJ21ME741		CIE Marks: 50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40 L		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	Elucidate the definition, advantages and classification of composite materials.
2	Recognize the matrix and reinforcements and their production routes.
3	Get familiarized with the properties and response of composite structures subjected to mechanical loading.
4	Gain knowledge on classification, processing, characterization and applications of composite materials.
5	Elucidate the various characterization techniques for composites and understand the various failure mechanisms.

UNIT-I	
Introduction To Composite Materials: Definition, history and classification of composite materials. Advantages and limitations, industrial scenario and applications. Materials - fibrous composites, laminated composites, particulate composites. Fiber Reinforced Plastic (FRP) Processing: Layup and curing, fabricating process, open and closed mould process, Hand layup techniques, structural laminate bag molding, production procedures for bag molding, filament winding, pultrusion, pulforming, thermo-forming, injection molding, blow molding. **Experiential Learning** • Hand layup fabrication of structural laminates of different composites. **Applications:** Study of Different FRP processing. **Video link / Additional online information:** https://www.youtube.com/watch?v=WgwDI1oOQNc	8 Hrs
UNIT-II	
Characteristics of Fiber Reinforced Lamina: Unidirectional fibre composites - Fiber characteristics. Longitudinal strength and modulus of composites, minimum and critical fibre volume fractions, factors affecting strength. Transverse strength and modulus. Introduction to Properties of Laminate and Failure Theories: Failure modes, Single and multiple fractures. Short-fibre composites: Stress transfer, critical fibre length. Modulus and strength. Whiskers and whisker reinforced composites. **Experiential Learning** • Case study on Unidirectional fibre composites and Laminate and Failure Theories. **Applications:** Study of Unidirectional fibre composites and Failure Theories. **Video link / Additional online information:** https://www.youtube.com/watch?v=7V1ym8hnB7k https://www.youtube.com/watch?v=R4SkUOzVDJA	8 Hrs
UNIT-III	
Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application.	8 Hrs

Fabrication Process for MMC's: Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques. **Experiential Learning** • Case study & Demonstration of Fabrication Process for MMC's. **Applications**: Case study on different Fabrication Process for MMC's. **Video link / Additional online information:** https://www.youtube.com/watch?v=RihoVfzEfWI	
UNIT-IV	
Ceramic Matrix Composites: Engineering ceramic materials, properties, advantages, limitations, Monolithic ceramics, Need for CMC, Ceramic matrix, Various types of Ceramic Matrix composites, oxide ceramics, non-oxide ceramics, aluminium oxide, silicon nitride reinforcements, particles, fibres, whiskers. Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing). Advanced composites: Nano composites, hybrid composites, sandwich composites, in-situ composites, smart composites, self-healing composites, and carbon carbon composites. **Experiential Learning** • Case study & Demonstration of Fabrication Process for CMC's. • **Applications**: Case study on different Fabrication Process for CMC's.. **Video link / Additional online information:** https://nptel.ac.in/courses/101104010/ https://www.youtube.com/watch?v=6ExJp0rdZiM https://nptel.ac.in/courses/112104229	8 Hrs
UNIT-V	
Testing and Characterization: Different tests tensile, compression, shear, fatigue, pull-out test, fracture toughness, metallographic preparation etc. with special emphasis to metal matrix composites, XRD and SEM. Secondary Processes and Applications: Secondary processing like machining, joining, extrusion of composites - Application and case studies. **Experiential Learning** • Case study & Demonstration of Testing and Characterization and Secondary Processes and Applications. **Applications**: Case study on Testing and Characterization Secondary Processes and Applications. **Video link / Additional online information:** https://nptel.ac.in/downloads/101104010/ https://www.industryhk.org/upload/media/file/9f0bdc4a82f044576a49a559d4b233fc	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Exhibit their knowledge on classification, processing, characterization and applications of various composite materials.
CO2	Show their ability to arrive at different deformation and failure mechanisms of composite materials under different loading conditions in engineering applications.
CO3	Decide the manufacturing methods for producing different types of MMC's.
CO4	Exhibit their ability to understand the properties, manufacturing methods of CMC's and to differentiate various types of advanced composite materials.

CO5	Select suitable testing procedures, carryout the characterization of composite materials and exhibit the knowledge of secondary processing of composites.

Reference Books	
1.	Autar K Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005.
2.	Composite Material Science and Engineering, Krishan K Chawla, Springer, 3e, 2012.
3.	Robert M Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.
4.	Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

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

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										2
CO2	3		2	2			1				2	1
CO3	2									2	1	2
CO4	3	2	1	2	1	2					2	2
CO5	2											1

Semester: VII		
PRODUCT DESIGN & ERGONOMICS (Theory)		
Course Code: MVJ21ME742		CIE Marks:100
Credits: L:T:P:S: 3:0:0		SEE Marks: 100
Hours: 40L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	Understanding the user-centred design process including form and colour theory.
2	Understanding product metamorphosis, and ergonomic
3	Implement the principles of ergonomics and how to apply the principles to industrial design
4	Understand the importance and techniques of human biological data collection and experiments.
5	Obtain a knowledge and ability towards Accident Investigation and Safety Management.

UNIT-I	
Introduction to Product Design: Asimows Model : Definition of product design, Design by Evaluation, Design by Innovation, Essential Factors of Product Design, Flow and Value Addition in the Production-Consumption Cycle. The Morphology of Design (The seven Phase), Primary Design phase and flowcharting, role of Allowance, Process Capability.	8 Hrs
UNIT-II	
Ergonomics and Industrial Design: Introduction -general approach to the man-machine relationship- workstation design-working position. Ergonomics and Production: ergonomics and product design –ergonomics in automated systems- expert systems for ergonomic design. Anthropometric data and its applications in ergonomic, design- limitations of anthropometric datause of computerized database. Case study	8 Hrs
UNIT-III	
Aesthetic Concepts: Concept of unity- concept of order with variety - concept of purpose style and environment, Aesthetic expressions. Style components of style- house style, observation style in capital goods, case study	8 Hrs
UNIT-IV	
Visual Effects of Line and Form: The mechanics of seeing- psychology of seeing general influences of line and form.	8 Hrs
UNIT-V	
Office Systems and Ergonomics, Ergonomics of Technology Management. Consumer Ergonomics, Ergonomics Quality and Safety, Quality of Life	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	To learn the concept of product design and the ergonomics.
CO2	. Design the various controls and displays by knowing the anthropometric data's.
CO3	To learn the psychology of visuals effects.
CO4	Learning the different colour combinations for optimal design of engineering equipments.
CO5	Realize the importance of environmental factors and aesthetics in industrial design.

Reference Books	
1.	Industrial Design for Engineers - Mayall W.H. - London Hiffee books Ltd. -1988.
2.	Introduction to Ergonomics - R. C. Bridger - McGraw Hill Publications - 1995.
3.	Human Factor Engineering - Sanders & McCormick – McGraw Hill Publications – 6th edition, 2002.
4.	Ulrich, Karl T, Eppinger, Steven D, 'Product Design and Development', McGraw-Hill, 2004.

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	-	-	-	3	3
CO2	3	2	3	3	-	-	-	-	-	2	3	3
CO3	3	2	3	3	-	2	2	-	-	2	3	3
CO4	2	3	3	-	-	2	2	-	-	2	3	3
CO5	3	3	3	2	-	-	-	-	-	-	3	3

Semester: III		
Additive Manufacturing (Theory)		
Course Code: MVJ21ME743		CIE Marks:100
Credits: L:T:P:S: 3:0:0		SEE Marks: 100
Hours: 40L		SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	To introduce students the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques	
2	To familiarize students with different processes in rapid prototyping systems.	
3	To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications.	

UNIT-I	
Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing. Classification of AM processes: Liquid polymer system, Discrete particle system, Molten material systems and Solid sheet system. Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. Guidelines for process selection: Introduction, selection methods for a part, challenges of selection AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=ICjQ0UzE2Ao	8 Hrs
UNIT-II	
System Drives and devices: Hydraulic and pneumatic motors and their features, Electrical motors AC/DC and their features Actuators: Electrical Actuators; Solenoids, Relays, Diodes, Thyristors, Triacs, Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents)	8 Hrs

https://www.youtube.com/watch?v=akZjDHD6JC4	
UNIT-III	
POLYMERS & POWDER METALLURGY Basic Concepts: Introduction to Polymers used for additive manufacturing: polyamide, PF resin, polyesters etc. Classification of polymers, Concept of functionality, Polydispersity and Molecular weight [MW], Molecular Weight Distribution [MWD] Polymer Processing: Methods of spinning for additive manufacturing: Wet spinning, Dry spinning. Biopolymers, Compatibility issues with polymers. Moulding and casting of polymers, Polymer processing techniques General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes. Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, Powder Structure, Chemical Characterization Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques. Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isotactic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting. Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=yHQX9GWCk6w	8 Hrs
UNIT-IV	
NANO MATERIALS & CHARACTERIZATION TECHNIQUES: Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology Nano-materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol-gel process; Gas Phase synthesis of Nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC). Optical Microscopy - principles, Imaging Modes, Applications, Limitations. Scanning Electron Microscopy (SEM) - principles, Imaging Modes, Applications, Limitations. Transmission Electron Microscopy (TEM) - principles, Imaging Modes, Applications, Limitations. X- Ray Diffraction (XRD) - principles, Imaging Modes, Applications, Limitations. Scanning Probe Microscopy (SPM) - principles, Imaging Modes, Applications,	8 Hrs

Limitations. Atomic Force Microscopy (AFM) - basic principles, instrumentation, operational modes, Applications, Limitations. Electron Probe Micro Analyzer (EPMA) - Introduction, Sample preparation, Working procedure, Applications, Limitations. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=lFYs3XDu4fQ	
UNIT-V	
MANUFACTURING CONTROL AND AUTOMATION CNC technology - An overview: Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC machine tools, Advantage, disadvantages of NC /CNC machine tools, Application of NC/CNC Part programming: CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc.), Special part programming, Advanced part programming, Computer aided part programming (APT) Introduction: Automation in production system principles and strategies of automation, basic Elements of an automated system. Advanced Automation functions. Levels of Automations, introduction to automation productivity Control Technologies in Automation: Industrial control system. Process industry vs discrete manufacturing industries. Continuous vs discrete control. Continuous process and its forms. Other control system components. Experiential Learning: (Experiments which can be conducted on the concepts of contents) Video Links/Any other special information(Papers): (For additional study on the concepts of contents) https://www.youtube.com/watch?v=PN_tGm5Gip4	Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe various CAD issues for 3D printing and rapid prototyping and related operations for STL model manipulation.
CO2	Formulate and solve typical problems on reverse engineering for surface reconstruction from physical prototype models through digitizing and spline-based surface fitting.
CO3	Formulate and solve typical problems on reverse engineering for surface reconstruction from digitized mesh models through topological modelling and subdivision surface fitting.
CO4	Explain and summarize the principles and key characteristics of additive manufacturing technologies and commonly used 3D printing and additive manufacturing systems.

CO5	Explain and summarize typical rapid tooling processes for quick batch production of plastic and metal parts.

Reference Books	
1.	Ian Gibson, David W. Rosen, Brent Stucker , "Additive Manufacturing Technologies" ,Springer,2009
2.	Chua C. K., Leong K. F., and Lim C. S., "Rapid Prototyping: Principles and Applications", Second Edition, World Scientific Publishers (2003)
3.	Patri K. Venuvinod, Weiyin Ma "Rapid Prototyping: Laser-Based and Other Technologies" Springer , 2004
4.	Burns. M, "Automated fabrication", Prentice-Hall,1993.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

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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.

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

Semester: VII		
Nano Technology (Theory)		
Course Code: MVJ21ME744		CIE Marks:50
Credits: L:T:P: 3:0:0		SEE Marks: 50
Hours: 40L		SEE Duration: 3 Hrs

Course Learning Objectives: The students will be able to	
1	To learn basic principles and methodologies of finite element analysis.
2	To understand the theory and characteristics of finite elements used in analysis of complexed engineering problems.
3	To introduce formulation of engineering problems into FEM by discretization process, polynomial, interpolation, application of boundary conditions, assembly of global arrays, solution of the resulting algebraic systems.
4	To apply finite element solutions to structural, thermal, dynamic problems to develop the knowledge and skills needed to effectively evaluate finite element analysis.
5	To learn basic principles and methodologies of finite element analysis.

UNIT-I	
Basic Elements of Nano-science and Nanotechnology: Engineering scale of nanotechnology, different classes of nano-materials, synthesis of nano-materials, fabrication and characterization of nanostructures, Engineering applications- Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture Industry.	8 Hrs
UNIT-II	
Nanotechnology and Ceramics : Introduction, Vapor Condensation Methods, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame Decomposition of metal organic Precursors methods	8 Hrs
UNIT-III	
Tools to characterize Nanomaterials: X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy,UV/Visible Spectroscopy	8 Hrs
UNIT-IV	
Surface Engineering: Introduction to surface engineering, Scope of surface engineering for different engineering materials, Surface Preparation methods such as Chemical, Electrochemical, Mechanical: Sand Blasting, Shot peening, Shot blasting, Hydro-blasting, Vapor Phase Degreasing etc., Coatings: Classification, Properties and applications of Various Coatings.	8 Hrs
UNIT-V	
Different methods for surface modifications: Surface modification by use of directed energy beams, Plasma, Sputtering & Ion Implantation. Surface modification by Friction stir processing. Surface composites	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	To comprehend basics of nano-science and technology and their applications in the domain of engineering.
CO2	To impart fundamental knowledge of various methods used in the field of nano-technology
CO3	To impart basics of various characterization tools/methods in the field of Nano-Technology
CO4	Explain the effect of process parameters on the properties & microstructure of the surface coating processes
CO5	Understand the importance & role of surface modifications to achieve several technological properties

Reference Books	
1.	Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004
2.	Nanoscale Science and technology by Robert Kelsall (editor), Ian W. Hamley (co-editor), Mark Geoghegan (co-editor) , ISBN: 978-0-470-85086-2
3.	The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.
4.	Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

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Semester End Examination (SEE):

Total marks: 50+50=100

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

Semester: VII		
Project Phase I		
Course Code: MVJ21MEP75		CIE Marks:50
Credits: 10		SEE Marks: 50
Hours: 03		SEE Duration:

Course Learning Objectives: The students will be able to	
1	To provide an opportunity and atmosphere in which students may test theory learned in the classroom in an actual working situation and discover the value of work and the rewards of accomplishment.
2	As a part of a team, the students will make a project, that emphasizes, hands-on experience, and integrates analytical and design skills.
3	To provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem.
4	Compile the results, discuss the findings and draw the conclusions for the project.
5	Prepare quality document of project work.

Sl. No	PHASES FOR PROJECT WORK
1	Introduction and Problem Definition
2	Summary of literature survey
3	Formulation of revised project objectives
4	Proposed Methodology and implementation
5	Results and discussion
6	Project report documentation
7	Oral presentation

Course outcomes:	
CO1	Perform literature review on par with international journal standards
CO2	Identify literature gap and define the problem.
CO3	Design experiments scientifically/perform numerical analysis/develop analytical models and interpret the results and apply advanced tools/techniques for solving the problem.
CO4	Compile the results, discuss the findings, and draw the conclusions for the project.
CO5	Prepare quality document of project work.

Reference Books:	
1.	J. P. Holman, "*Experimental Methods For Engineers*", McGraw-Hill Companies, Eighth edition, 2012.
2.	Prasanna Chandra, "*Projects- Appraisal, Preparation, Budgeting and Implementation*", McGraw-Hill Companies, 1987.

Scheme of Examination:	
1.	Relevance of the topic: 10 marks
2.	Report: 20 marks
3.	Evaluation by Guide: 25 marks
4.	Presentation: 30 marks
5.	Viva – Voce: 15 marks

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

High-3, Medium-2, Low-1

Semester: VIII		
Project Phase II		
Course Code: MVJ21MEP81		CIE Marks:50
Credits: 10		SEE Marks: 50
Hours: 03		SEE Duration: 3 hrs

Course Learning Objectives: The students will be able to	
1	To provide an opportunity and atmosphere in which students may test theory learned in the classroom in an actual working situation and discover the value of work and the rewards of accomplishment.
2	As a part of a team, the students will make a project, that emphasizes, hands-on experience, and integrates analytical and design skills.
3	To provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem.
4	Compile the results, discuss the findings and draw the conclusions for the project.
5	Prepare quality document of project work.

Sl. No	PHASES FOR PROJECT WORK
1	Introduction and Problem Definition
2	Summary of literature survey
3	Formulation of revised project objectives
4	Proposed Methodology and implementation
5	Results and discussion
6	Project report documentation
7	Oral presentation

Course outcomes:	
CO1	Perform literature review on par with international journal standards
CO2	Identify literature gap and define the problem.
CO3	Design experiments scientifically/perform numerical analysis/develop analytical models and interpret the results and apply advanced tools/techniques for solving the problem.
CO4	Compile the results, discuss the findings and draw the conclusions for the project.
CO5	Prepare quality document of project work.

Reference Books:	
1.	J. P. Holman, "*Experimental Methods For Engineers*", McGraw-Hill Companies, Eighth edition, 2012.
2.	Prasanna Chandra, "*Projects- Appraisal, Preparation, Budgeting and Implementation*", McGraw-Hill Companies, 1987.
Scheme of Examination:	
1.	Relevance of the topic: 10 marks
2.	Report: 20 marks
3.	Evaluation by Guide: 25 marks
4.	Presentation: 30 marks
5.	Viva – Voce: 15 marks

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

High-3, Medium-2, Low-1

Semester: VIII		
Research / Industrial Internship (Theory and Practice)		
Course Code: MVJ21INT82		CIE Marks: 50
Credits: 05		SEE Marks: 50
Hours:		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	Get an inside view of an industry and organization/company
2	Gain valuable skills and knowledge
3	Make professional connections and enhance student's network
4	Get experience in a field to allow the student to make a career transit
5	To build a record of work experience and construct a good relationship with the employers.

Guidelines

- Students have to undergo this training for a period of 6 weeks (minimum) during the vacation between even and odd semesters.
- Those students who are unable to complete during these periods will have to undergo the internship after VIII semester and VIII semester grade card will be issued only after the successful completion of internship by that student
- The department shall nominate a faculty as a mentor for a group of students to prepare and monitor the progress of the students
- The students shall report the progress of the internship to the mentor/guide at regular intervals and may seek his/her advice.
- After completion of Internship, students shall submit a report to the department with the approval of both internal and external guides/mentors.
- Evaluation of Internship shall be conducted during VIII semester by internal and external examiners for 100 marks.
- The external examiner shall be from the industry where the student carried out the internship. In case of non-availability of external examiner, the concerned head of the department shall appoint an external examiner from the nearby college or a senior faculty member from outside the department in consultation with respective BOE and approved by Principal
- The internship carries three credits. A student has to get a minimum of 40% marks for a pass. If the student fails to complete the same, then internship has to be repeated in its entirely
- The breakup of marks for the evaluation of training is as in table.

Evaluation by the supervisor under whom the training was carried out	25 Marks
Evaluation by DSEC	
4. Relevance of the Field training/Industrial Internship	10 Marks
5. Report	25 Marks
6. Evaluation	40 Marks
Total	100

Course outcomes:

CO1	To experience a 8 weeks' internship training, enabling the student for onsite visits, study projects and practical training.
CO2	To develop a skill for handling multiple situations, practical problems, analyzing teamwork and communication abilities
CO3	To integrate theory with practice and carry out performance objectives on strong work ethics, persistence, adaptability and critical
CO4	To analyze work environment and create solution to problems.
CO5	To build a record of work experience and construct a good relationship with the employers.

Reference Books:	
1	T1. Pamela Myers Kiser, "Human Services Internship: Getting the Most From Your Experience", Cengage Learning, 4th Edition, 2016. (ISBN13: 978-1305087347)

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

High-3, Medium-2, Low-1

Semester: VIII		
Seminar		
Course Code: MVJ21MES83		CIE Marks:50
Credits: 01		SEE Marks: 50
Hours:		SEE Duration: 03

Course Learning Objectives: The students will be able to	
1	To equip students for making a technical presentation based on a thorough re-search review on any contemporary area of Engineering and Management fields.
2	Offering the student an opportunity to interact with faculty and peer group and to build the ability to making independent presentation.

STAGES OF SEMINAR

i) Identification of seminar topic related to area of interest in the field of advanced Mechanical Engineering.
ii) Case studies related to selected topics.
iii) Final seminar will start from 6th week of the semester in the department before the Departmental Evaluation Committee constituted by HOD.
iv) The seminar marks are to be awarded by the committee.
v) Students shall submit the seminar report in the prescribed standard format.

Course Outcomes: After completing the course, the students will be able to	
CO1	Conduct literature survey on a current topic based on peer reviewed literature and identify research gap in the literature.
CO2	Develop methodologies to resolve the identified problem(s).
CO3	Develop presentation slides / report arranging the material coherently and discuss the topic with clarity and confidence.
CO4	Summarize the presentation, submit the report and identify scope for further work.

Continuous Internal Evaluation (CIE):

SCHEME OF EVALUATION				
	MARKS ALLOTED			
PARTICULARS	MAX MARKS	EVALUATOR 1	EVALUATOR 2	AVERAGE
Report	15			
Relevance of topic with the program	10			
Oral presentation & Etiquette	15			
Viva Voce	10			
TOTAL	50			

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