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
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		
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		
TRIBOLOGY (Theory)		
Course Code: MVJ21ME725		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	Describe the Lubrication principle and mechanisms.
2	Finding the load carrying capacity in light and heavy loaded journal bearings.
3	Friction force and power loss Analysis in hydrodynamic and hydrostatic lubrication.
4	Identify the appropriate material for bearings based on the application.
5	Study the different wear mechanism in tribological components.

UNIT-I	
Pre-requisites: Mechanics of Materials, Engineering Mathematics, Engineering Chemistry, Fluid Mechanics Design of Machine Elements I & II. **Introduction to Tribology:** Properties of oils and equation of flow: Viscosity, Newton's Law of viscosity, Hagen-Poiseuille Law, Flow between parallel stationary planes, viscosity measuring apparatus. Lubrication principles, classification of lubricants. **Laboratory Sessions/ Experimental learning:** Finding out the viscosity of different liquids (oils). **Applications:** It can be used in bearings, brakes, seals and cams. **Video link / Additional online information (related to module if any):** 1.https://nptel.ac.in/courses/112102014/ 2.https://www.nptel.ac.in/courses/112102015/ 3.http://www.nptelvideos.in/2012/12/tribology.html	8 Hrs
UNIT-II	
Hydrodynamic Lubrication: Friction forces and power loss in lightly loaded bearing, Petroff's law, Tower's experiments, idealized full journal bearings. **Mechanism of Pressure Development in an Oil Film:** Reynold's investigations, Reynold's equation in two dimensions, Partial journal bearings, end leakages in journal bearing, Numerical problems. **Laboratory Sessions/ Experimental learning**: Finding the Friction loss and power loss in journal bearings **Applications**: These concepts are used for lubrication purpose for automobile vehicles. **Video link / Additional online information (related to module if any):** 1. https://www.nptel.ac.in/courses/112102015/ 2. https://nptel.ac.in/courses/112/102/112102014/	8 Hrs
UNIT-III	
Slider / Pad Bearing with a Fixed and Pivoted Shoe:	8 Hrs

Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a pivoted shoe bearing, influence of end leakage, numerical examples. **Laboratory Sessions/ Experimental learning**: Study of load carrying capacity in bearings. **Applications**: These concepts are used for lubrication purpose for automobile vehicles. **Video link / Additional online information (related to module if any)**: 1.http://www.nptelvideos.in/2012/12/tribology.html 2.https://www.youtube.com/watch?v=hNfgnX2lA18	
UNIT-IV	
Hydrostatic Lubrication: Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing. **Bearing Materials**: Commonly used bearings materials, properties of typical bearing materials. **Laboratory Sessions/ Experimental learning**: Selection of proper of bearing materials according to applications. **Applications**: Applied for Nano materials, composite materials. **Video link / Additional online information (related to module if any)**: 1. https://nptel.ac.in/courses/112102014/ 2. https://www.youtube.com/watch?v=HTIzwP8BKC8	8 Hrs
UNIT-V	
Wear: Introduction, Types of Wear Mechanism: Adhesive Wear- Quantitative Equations-Experimental Evidence- Role of Metallurgical Compatibility-Structural Effects-Grain Boundary Effects, Abrasive Wear(by Plastic Deformation and Fracture)-Abrasive Wear by Plastic Deformation-Quantitative Equation-Effect of Relative Hardness of Abrasive Medium to Workpiece , Fatigue Wear-Rolling Contact. **Fatigue**-Static Fatigue, Impact Wear-Solid Particle Erosion- Quantitative Equations- Cavitation Erosion- Percussion, Chemical (Corrosive) Wear-Tribochemical Wear, Fretting and Fretting Corrosion. **Laboratory Sessions/ Experimental learning**: Study of Abrasive Wear (by Plastic Deformation and Fracture) and safety measurements **Applications**: Applies for wear and tear of different materials, fatigue strength. **Video link / Additional online information (related to module if any)**: 1. http://www.nptelvideos.in/2012/12/tribology.html 2. https://ocw.mit.edu/courses/mechanical-engineering/2-800-tribology-fall-2004/lecture-notes/	8 Hrs

Course Outcomes: After completing the course, the students will be able to	
CO1	Realize and describe the Lubrication principle and mechanisms.
CO2	Compute load carrying capacity in light and heavy loaded journal bearings.

CO3	Analyse the friction force and power loss in hydrodynamic and hydrostatic lubrication.
CO4	Identify the appropriate material for bearings based on the application.
CO5	Recognize the different wear mechanism in tribological components

Reference Books	
1.	Redzimovskay E I., "Lubrication of Bearings – Theoretical Principles and Design" Oxford press company 2000
2.	Fundamentals of Tribology , Basu S K., Sengupta A N., Ahuja B. B., 2006, PHI .
3.	Handbook of tribology: materials, coatings and surface treatments, B.Bhushan, B.K. Gupta, McGraw-Hill,1997
4.	Introduction to Tribology Bearings ,Mujumdar B. C., 2008, S. Chand company pvt. Ltd

Continuous Internal Evaluation (CIE):

Theory for 50 Marks

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

Semester End Examination (SEE):

Total marks: 50+50=100

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

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	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		
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.	8 Hrs

Applications: DOE for the FMCG industry during its product development 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	8 Hrs

Control, Noise and Vibration in Off-Road Vehicle Interiors-Prediction and Control,	
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	8 Hrs

Video Links: https://www.youtube.com/watch?v=iV8XxRkW2NY https://www.youtube.com/watch?v=pZGv5MG3LBc	
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)	8 Hrs

https://www.youtube.com/watch?v=JwhEcrsM2QU https://www.youtube.com/watch?v=MIByupl3EY8	

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	Hrs: 8

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** **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		
Refrigeration and Air conditioning (Theory)		
Course Code: MVJ21ME735		CIE Marks:100
Credits: L:T:P: 3:0:0		SEE Marks: 100
Hours: 4OL		SEE Duration: 3 Hrs
Course Learning Objectives: The students will be able to		
1	Study the basic definition, ASHRAE Nomenclature for refrigerating systems	
2	Understand the working principles and applications of different types of refrigeration systems	
3	Study the working of air conditioning systems and their applications	

UNIT-I	
Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air. Industrial Refrigeration-Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous. Laboratory Sessions/ Experimental learning: • Recognize important standards of Refrigeration and Air conditioning systems available in Heat transfer lab. Applications: International and Indian Standards and nomenclatures are required to be understood. Video link / Additional online information: https://youtu.be/4mWsRUr0A7A	08
UNIT-II	
Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle– liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing's construction and Gosney's method. Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling. Laboratory Sessions/ Experimental learning: • An experiment to be conducted on VCR experimental setup available in Heat transfer lab to illustrate the working of a typical VCR system. Applications: The practical difficulties in application of working principles and applications of VCR refrigeration system.	08

Video link / Additional online information: https://youtu.be/XO2PBDMEHfs, https://youtu.be/WodVKkkWz90	
UNIT-III	
Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems. Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermoacoustic refrigeration systems. **Laboratory Sessions/ Experimental learning:** • An experiment to be conducted on VAR experimental setup available in Heat transfer lab to illustrate the working of a typical VAR system. **Applications**: The practical difficulties in application of working principles and applications of VAR refrigeration system. **Video link / Additional online information:** https://youtu.be/4w3Obp8ILpA	08
UNIT-IV	
Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures. Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system. **Laboratory Sessions/ Experimental learning:** • Find a suitable refrigerant for requirements of refrigeration system. **Applications**: Identify suitable refrigerant for various refrigerating systems. **Video link / Additional online information:** https://youtu.be/6_ePn_LkIQM	08
UNIT-V	
Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Psychrometry Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air- Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems. Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships. **Laboratory Sessions/ Experimental learning:** • Design an Air-condition system for requirements provided.	08

Applications: Compute and Interpret cooling and heating loads in an air-conditioning system. **Video link / Additional online information**: https://youtu.be/nvUhiXD63Eg, https://nptel.ac.in/courses/112/105/112105128/	

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate the principles, nomenclature and applications of refrigeration systems.
CO2	Explain vapor compression refrigeration system and identify methods for performance improvement.
CO3	Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo- acoustic refrigeration systems
CO4	Identify suitable refrigerant for various refrigerating systems
CO5	Compute and Interpret cooling and heating loads in an air-conditioning system.

Reference Books	
1.	Stoecker W.F., and Jones J.W., "*Refrigeration and Air-conditioning*", Mc Graw - Hill, New Delhi 2nd edition, 1982 ISBN 13: 9780070616196, ISBN 10: 0070616191
2.	Roy J. Dossat, "*Principles of Refrigeration*", Wiley Limited, 1997, ISBN: 9780132333719, 0132333716
3.	Mc Quistion, *"Heating, Ventilation and Air Conditioning"*, Wiley Students edition,5th edition 2000, ISBN 13: 9780471470151
4.	Arora C.P., "*Refrigeration and Air-conditioning*", Tata Mc Graw –Hill, New Delhi, 2nd Edition, 2001. ISBN 13: 9780070083905, ISBN 10: 0070083908

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	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: 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	8 Hrs

https://www.youtube.com/watch?v=R4SkUOzVDJA	
UNIT-III	
Metal Matrix Composites: Reinforcement materials, types, characteristics and selection base metals selection. Need for production MMC's and its application. 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	8 Hrs
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)	8 Hrs

Video Links/Any other special information(Papers): (For additional study on the concepts of contents) 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	8 Hrs

Diffraction (XRD) - principles, Imaging Modes, Applications, Limitations. Scanning Probe Microscopy (SPM) - principles, Imaging Modes, Applications, 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

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												
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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

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

Semester End Examination (SEE):

Total marks: 50+50=100

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

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	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		
SUPPLY CHAIN MANAGEMENT		
Course Code: MVJ21ME745		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, 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 omnichannel customer-driven landscape)	8 Hrs
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. 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	8 Hrs
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	
1.	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
2.	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

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Semester End Examination (SEE):

Total marks: 50+50=100

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

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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: VII		
Project Phase I		
Course Code: MVJ21MEP76		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												
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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