VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M. Tech., Design Engineering. (MDE)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M. Tech., Design Engineering (MDE)
Choice Based Credit System (CBCS) and Outcome-Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	BSC	22 MDE/ MMD /MEA11	Mathematical Methods in Engineering	03	00	00	03	50	50	100	3
2	IPCC	22MDE12	Computer Simulation of Machines	03	02	00	03	50	50	100	4
3	PCC	22MDE13	Plates, Thin Film Analogy and Contact Stresses	03	00	02	03	50	50	100	4
4	PCC	22MDE14	Signal Analysis and Condition Monitoring	02	00	02	03	50	50	100	3
5	PCC	22MDE15	Mechatronics	02	00	02	03	50	50	100	3
6	MCC	22RMI16	Research Methodology and IPR	03	00	00	03	50	50	100	3
7	PCCL	22MDEL17	Instrumentation and Experimental Stress Analysis Laboratory	01	02	00	03	50	50	100	2
8	AUD/ AEC	22AUD18/ 22AEC18	BoS recommended ONLINE courses	Classes and evaluation procedures are as per the policy of the online course providers.							PP
			TOTAL	**17**	**04**	**06**	**21**	**350**	**350**	**700**	**22**

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC- Mandatory Credit Course, AUD/AEC –Audit Course / Ability Enhancement Course(A pass in AUD/AEC is mandatory for the award of the degree), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Integrated Professional Core Course (IPCC): **Integrated Professional Core Course (IPCC)**: Refers to Professional Theory Core Course Integrated with practical of the same course. The theory part of the IPCC shall be evaluated both by CIE and SEE. The practical part shall be evaluated by only CIE (no SEE). However, questions from the practical part of IPCC shall be included in the SEE question paper.

Audit Courses /Ability Enhancement Courses Suggested by BoS (ONLINE courses): Audit Courses: These are prerequisite courses suggested by the concerned Board of Studies. Ability Enhancement Courses will be suggested by the BoS if prerequisite courses are not required for the programs.

Ability Enhancement Courses:

- These courses are prescribed to help students to enhance their skills in in fields connected to the field of specialisation as well allied fields that leads to employable skills. Involving in learning such courses is impetus to lifelong learning.
- The courses under this category are online courses published in advance and approved by the concerned Board of Studies.
- Registration to Audit /Ability Enhancement Course shall be done in consultation with the mentor and is compulsory during the concerned semester.
- In case a candidate fails to appear for the proctored examination or fails to pass the selected online course, he/she can register and appear for the same course if offered during the next session or register for a new course offered during that session, in consultation with the mentor.
- The Audit Ability Enhancement Course carries no credit and is not counted for vertical progression. However, a pass in such a course is mandatory for the award of the degree.

Skill development activities: Under Skill development activities in a concerning course, the students should

1. Interact with industry (small, medium, and large).
2. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
3. Involve in case studies and field visits/ fieldwork.
4. Accustom to the use of standards/codes etc., to narrow the gap between academia and industry.
5. Handle advanced instruments to enhance technical talent.
6. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyse and authenticate the output to interpret and conclude.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.Students and the course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills of the study they have undertaken. The students with the help of the course teacher can take up relevant technical –activities which will enhance their skill. The prepared report shall be evaluated for CIE marks.

Program Outcomes (POs)

1. **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.

2. **PO2:** An ability to write and present a substantial technical report/document.

3. **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.
4. **PO4**: Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.
5. **PO5**: Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions

I SEMESTER

MATHEMATICAL METHODS IN ENGINEERING Common To MDE/MMD/MEA			
Course Code	22 MDE11	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

This course will enable students to

1. Know how to Model and Solve, Ordinary Differential Equations of First and Second Order.
2. Understand Linear Algebra and its Applications.
3. Apply the Calculus of Variation for Engineering Applications
4. Use the Methods of Complex Analysis for Engineering

MODULE-1 (9 Hours)

First-Order ODEs: Basic Concepts - Modeling, Concept of Solution, Initial Value Problem, Geometric Meaning of Direction Fields, Euler's Method, Separable ODEs.

Second-Order Linear ODEs: Homogeneous Linear ODEs with Constant Coefficients, Modeling of Free Oscillations of a Mass–Spring System, Nonhomogeneous ODEs, Modeling: Forced Oscillations. Resonance. Modeling: Electric Circuits. Solving the ODE for the Current in an RLC-Circuit.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-2 (9 Hours)

Partial Differential Equations: Basic Concepts of PDEs, Modeling: Vibrating String (Wave Equation), Solution by Separating Variables, D'Alembert's Solution of the Wave Equation and Characteristics, Modeling: Heat Flow from a Body in Space (Heat Equation), Heat Equation: Solution by Fourier Series.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-3 (7 Hours)

Linear Algebra: Matrices, Vectors, Matrix Multiplication, Linear Systems of Equations, Gauss Elimination, Linear Independence. Rank of a Matrix. Vector Space, Solutions of Linear Systems:

Existence, Uniqueness, Determinants. Cramer's Rule, Inverse of a Matrix. Gauss–Jordan Elimination, Determining, Eigenvalues and Eigenvectors, Some Applications of Eigenvalue Problems.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-4 (8 Hours)

Complex Numbers, Functions and Differentiation: Geometric Representation, Polar Form of Complex Numbers, Powers and Roots, Analytic Function, Cauchy–Riemann Equations, Exponential Function, Trigonometric and Hyperbolic Functions.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-5 (7 Hours)

Calculus of Variation: Introduction, Examples of Simple Functionals, The first Variation (Euler - Lagrange Equation), The Delta operator,Geodesics and hanging chain problem.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons. 2011
2. Door Irving Herman Shames, Clive L. Dym , "Energy and Finite Element Methods in Structural Mechanics", 1st Edition, 2015 Reprint, New Age International.

Web links and Video Lectures (e-Resources):

1. Differential Equations for Engineers https://archive.nptel.ac.in/courses/111/106/111106100/
2. Ordinary and Partial Differential Equations and Applicationshttps://onlinecourses.nptel.ac.in/noc22_ma02/preview

Skill Development Activities Suggested

1. Solve an ODE using the MATLAB function ODE45 and obtain the graphical solution
2. Model a Spring-Mass- Damper system in MATLAB / SCILAB or in any similar software

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Model and find the solutions for First Order and Second Order ODEs	3
CO2	Solve the system of Linear Equations using Gauss Elimination and Cramer's rule	3
CO3	Apply the concepts of complex number theory	3
CO4	Generate and find solutions to Functionals.	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	1
2	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**			**2**	
CO2	**3**			**2**	
CO3	**3**			**2**	
CO4	**3**			**2**	

Note : High - 1, Medium – 2, and Low – 3

COMPUTER SIMULATION OF MACHINES			
Course Code	**22MDE12**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab Sessions	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

This course will enable students to

1. Know the concepts used for kinematic analysis of planar and spatial mechanisms.
2. Familiarize with the concepts of synthesis of mechanisms.

MODULE-1 (8 Hours)

Introduction, Overview, Why Simulate Mechanisms, Kinematics Simulations, Dynamic Simulation of Mechanisms, Summary, Vector Loop and Vector Chain Equations –Introduction, The Planar Vector, Single Loop Equations, Derivatives of Vectors, Other CommonMechanisms, Vector Chains.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-2(8 Hours)

Introduction to synthesis (analytical methods) - Freudenstein's equation - Precision point, approximation - Precision derivative approximation - Method of components - Block synthesis and Reven's method.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-3 (8 Hours)

Graphical Synthesis Techniques: Motion generation for two prescribed positions and three prescribed positions – path generation for three prescribed positions without and with prescribed timing – function generation for three prescribed positions.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-4 (8 Hours)

Analytical Synthesis Techniques: Four bar and slider crank function generator with three accuracy points– use of complex numbers and dyads – three prescribed positions for motion, path and function generation using dyad.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-5 (8 Hours)

Two-link planar Robot: Overview, Vector Equations, Dynamic Equations, The Simultaneous Constraint matrix, Dynamic Simulation, Robot Coordinate Control.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

PRACTICAL COMPONENT OF IPCC

Sl.NO.	Experiments
1	Basics of Kinematic/ Multi-body Simulation Software: Falling Stone, Inclined Plane, Lift Mechanism
2	One-degree-of-freedom: Simulation of Mechanisms
3	Suspension System , Four Bar Velocity
4	Cam-Follower, Crank Slider
5	Valve-train Mechanism, Cam-rocker-valve
6	Stamping Mechanism, Robot Arm
7	Adams Optimization, Airplane Control Surface
8	Gyroscope and Power Hacksaw Mechanism
	Demonstration Experiments (For CIE)
9	Walking Beam Indexer
10	Watt's Linkage in a Steam Engine
11	Open Differential
12	Planetary Gear Sets Modification
Books:Adams Tutorial Kit for Mechanical Engineering Courses	

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

- Two Tests each of **20 Marks**
- Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
- Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

- The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Books

1. Uicker, Pennock and Shigley," Theory of machines and Mechanisms", Oxford University Press, 2010.
2. Amitabha Ghosh and Ashok Kumar Mallik, "Theory of Mechanism and machines", East West Press pvt Ltd, 2nd edition.
3. S.S. Rattan, "Theory of Machines", Tata McGraw Hill, 2011.

Web links and Video Lectures (e-Resources):

1. NOC:Kinematics of Mechanisms and Machines, IIT Kharagpur https://nptel.ac.in/courses/112105268
2. Kinematics Of Machineshttps://www.youtube.com/watch?v=MJeRFzs4oRU&list=RDCMUC640y4UvDAlya_WOj5U4pfA&index=2

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Write a MATLAB Program for kinematic analysis of Fourbar mechanism
2. Write a program in MATLAB to simulate the forward kinematics of a 2R Robotic Arm.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss the necessity for simulation of the mechanisms.	2
CO2	Apply analytical and synthesis techniques in design of mechanisms.	4
CO3	Apply techniques in kinematic synthesis of robot mechanism	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
4	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5
CO1	3	-	1	2	1
CO2	3	-	1	1	2
CO3	3	-	1	3	2

Note : High - 1, Medium – 2, and Low – 3

PLATES, THIN FILM ANALOGY AND CONTACT STRESSES			
Course Code	**22MDE13**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	40+ 10-12 Activities	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

1. To educate about the concepts of design of plates
2. To understand the application of thin film analogy in stress analysis
3. To study the effect of stress concentration
4. To understand the basic concepts of contact stress

MODULE-1(8Hours)

Flat plates: Introduction - Stress resultants in a flat plate - Kinematics: Strain - Displacement relations for plates - Equilibrium equations for small displacement theory of flat plates - stress strain- temperature relations for isotropic elastic plates - Strain energy of a plate - Boundary conditions for plates - Solutions of rectangular and circular plate problems.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-2(8 Hours)

Torsion: Torsion of cylindrical bar of circular cross-section Saint-Venant's semi-inverse method - Linear elastic solution - The Prandtl elastic - Membrane (soap-film) analogy - Narrow rectangular cross-section - Hollow thin-wall torsion members: Multiply connected cross-section - Thin-wall torsion members with restrained ends - Fully plastic torsion.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-3(8 Hours)

Beams on elastic foundation: General theory - Infinite beam subjected to concentrated load: Boundary conditions - Infinite beam subjected to a distributed load segment - Semi-infinite beam subjected to loads of its end - Semi-infinite beam with concentrated load near its end - Short beams - Thin-wall circular cylinders.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-4(8 Hours)

Stress concentrations: Basic concepts - Nature of a stress concentration problem. Stress concentration factor - Stress concentration factor, Experimental techniques The stationary crack - Crack propagation, Stress intensity factor, Applications.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-5(8 Hours)

Contact stresses: Introduction - The problem of determining contact stresses - Assumptions on which a solution for contact stresses is based - Notation and meaning of terms - Expressions for principal stresses - Method of computing contact stresses - Deflection of bodies in point contact - Stress for two bodies in contact over narrow rectangular area (line contact). Loads normal to area - Stresses for two bodies in line contact. Loads normal and tangent to contact area.	
Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Advanced Mechanics of Materials by Boresi, A.P. and Sidebottm, O.M.
2. Advanced Mechanics of Materials by Seely and Smith.
3. Advanced Strength of Materials by Den Hartog.
4. Advanced Strength of Materials by Timoshenko S.P.
5. Advanced strength of materials / Den Hortog J.P./Torrent
6. Theory of Plates /Timoshenko
7. Strength of materials / Sadhu singh/ Khanna Publishers
8. Mechanics of Materials / Beer &Jhonson / McGraw Hill
9. 9. Theory of Plates & Shells / Timoshenko/ McGraw Hill/ 2nd Editio

Web links and Video Lectures (e-Resources):

1. Plates and Shells (https://archive.nptel.ac.in/courses/105/103/105103209/)

Skill Development Activities Suggested

1. Review of papers on Theory of Plates, Thin film techniques, Fracture mechanics and contact stresses
2. Writing a report or paper and presenting in conference

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss the theories involved in the design of plates and shells	2
CO2	Apply the concept of thin film analogy and stress concentration	3
CO3	Apply the contact stress theory to contacting bodies	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research /investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
4	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**		**1**	**3**	**2**
CO2	**3**		**1**	**2**	**1**
CO3	**3**		**1**	**3**	**2**

Note : High - 1, Medium – 2, and Low – 3

SIGNAL ANALYSIS AND CONDITION MONITORING			
Course Code	**22MDE14**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To study and understand signal and its types
2. To understand the techniques involved in signal conditioning
3. To know the different used in structural health monitoring

MODULE-1(5 Hours)

Introduction: Basic concepts. Fourier analysis. Bandwidth. Signal types. Convolution.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-2 (5 Hours)

Signal analysis: Filter response time. Detectors. Recorders. Analog analyzer types.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-3 (5 Hours)

Practical analysis of stationary signals: Stepped filter analysis. Swept filter analysis. High speed analysis. Real-time analysis.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-4 (4 Hours)

Practical analysis of continuous non-stationary signals: Choice of window type. Choice of window length. Choice of incremental step. Practical details. Scaling of the results.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-5 (6 Hours)

Condition monitoring techniques: Visual monitoring, Thermography, Vibration monitoring, Shock pulse monitoring, Wear debris monitoring, Motor current and signature analysis, Acoustic emission, Ultrasound monitoring, ISO standards, Fault detection sensors, Structural Health M0nitoring (SHM), integrated Vehicle Health Monitoring (IVHM).

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. R. B. Randall, "Frequency Analysis", Brüel & Kjaer, 1987.
2. V. Ramamurti , Mechanical Vibration Practice with Basic Theory, Narosa Publishing House, 2000
3. A. R. Mohanty, Machinery Condition Monitoring: Principles and Practices (ISBN: 9781466593046) CRC Press, 2014.
4. Richard G. Lyons, "Understanding digital signal processing", Pearson; third edition (1 November 2010).
5. Alan V.Oppenheim , Alan S.Willsky, S.Hamid Nawab, "Signal and System",2nd Edition, Pearson.

Web links and Video Lectures (e-Resources):

1. NPTEL Video Lectures: Machinery Condition Monitoring and Signal Processing by A R MOHANTY

Skill Development Activities Suggested

1. Industrial visit / internship to gain hands-on experience on various Condition Monitoring methods.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss different types of signals generated	2
CO2	Apply the various techniques for signal conditioning	3
CO3	Apply various condition monitoring techniques	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Write and Present a report	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**2**		**1**	**2**	**2**
CO2	**2**		**1**	**3**	**3**
CO3	**2**		**1**	**2**	**2**

Note : High - 1, Medium – 2, and Low – 3

MECHATRONICS

Course Code	**22MDE15**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand the need and application of Mechatronics
2. To know the types of sensors and actuators used in automation
3. To study the different signal conditioning and control systems
4. To understand the applications of PLC

MODULE-1 (5 Hours)

Introduction: Overview, History of mechatronics, Scope and significance of Mechatronics systems, elements of Mechatronic systems, Needs and benefits of Mechatronics in manufacturing.

Sensors: Classification of sensors basic working principles, displacement sensor – linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders, Proximity and range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, hall Effect sensor, inductive Proximity switch, Light sensors – Photodiodes, Phototransistors, Flow Sensors – ultrasonic Sensor, Laser Doppler Anemometer, Tactile Sensors – PVDF tactile sensor, microswitch and reed switch, Piezoelectric sensors, Vision Sensor

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-2 (5 Hours)

Actuators: Electrical Actuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo Motor, BLDC Motor, AC Motor, Stepper Motor, Hydraulic & pneumatic devices – Power supplies, valves, Cylinder sequencing, Design of hydraulic & pneumatic circuits. PiezoElectric Actuators, Shape memory alloys.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-3(5 Hours)

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, multiplexer, Pulse width modulation counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-4 (5 Hours)

Controllers: Classification of Control systems, Feedback, Closed loop and open loop systems

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

MODULE-5 (5 Hours)

PLC Programming: PLC Principles of operation, PLC sizes, PLC hardware components, I/O section Analog I/O section, Analog I/O modules, digital I/O modules, CPU processor memory, module programming, Ladder Programming, ladder diagrams, Timers, Internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems

Teaching-Learning Process	Power-point Presentation, Video demonstration or Simulations, Chalk and Talk are used for Problem Solving, Laboratory Demonstrations and Practical Experiments

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

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Suggested Learning Resources:

Books

1. W. Boton, "Mechatronics", 5th edition, Adison Wesley Longman limited, 2010.
2. Devdas Shetty and Richard A. Kolk, Mechatronics system design, P.W.S. Publishing company, 2001.
3. Alciatore David G & Histand Michael B, "Introduction to Mechatronics and Measurement systems", 4th edition, Tata McGraw Hill, 2006.
4. Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications ", 2nd edition, Pearson Education India, PHI, 2003.

Web links and Video Lectures (e-Resources):

1. NPTEL Courses on Mechatronics By Prof. Pushparaj Mani Pathak , IIT Roorkee, https://onlinecourses.nptel.ac.in/noc21_me27/preview

Skill Development Activities Suggested

1. Visit to the industries
2. Use of simulation software for signal conditioning and PLC programming

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Illustrate various components of Mechatronics systems.	2
CO2	Appy the concepts of various control systems used in automation	3
CO3	Develop mechanical, hydraulic, pneumatic and electrical control systems using PLC	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Write and Present a report	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**--**	**1**	**2**	**3**
CO2	**3**	**-**	**1**	**2**	**2**
CO3	**3**	**-**	**1**	**2**	**3**

RESEARCH METHODOLOGY AND IPR			
Course Code	**22RMI16**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, and also different methods of data collections.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights

MODULE-1(10 Hours)

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration. 10Hrs

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(10 Hours)

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. 10Hrs

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(10 Hours)	
Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs. **Measurement and Scaling:** Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Techniques, Multidimensional Scaling, Deciding the Scale. **Data Collection:** Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method. 10Hrs	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-4(10 Hours)	
Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. **Chi-square Test**: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests. 10Hrs	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-5(10 Hours)	

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. **Intellectual Property:** The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers‟ Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation(WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules,Patents,Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the RightHolder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.10Hrs	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. C.R. Kothari, Gaurav Garg, "Research Methodology: Methods and Techniques", New Age International, 4th Edition, 2018.
2. Ranjit Kumar, "Research Methodology a step-by-step guide for beginners", SAGE Publications, 3rd Edition, 2011 (For the topicReviewing the literature under module 2)
3. Study Material - Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries ofIndia, Statutory Body Under an Act of Parliament, September 2013. (For the topic Intellectual Property under module 5)
4. William M. K. Trochim ;1st Edition, illustrated ; Publisher, Atomic Dog Pub., 2005
5. Fink A, "Conducting Research Literature Reviews: From the Internet to Paper", Sage Publications, 20112009.

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/127/106/127106227/
- https://www.youtube.com/watch?v=GSeeyJVD0JU

Skill Development Activities Suggested

1. Skill Development Activities Suggested:
2. Interact with industry (small, medium, and large).
3. Involve in research/testing/projects to understand their problems and help creative and innovative methods to solve the problem.
4. Involve in case studies and field visits/ fieldwork.
5. to the use of standards/codes etc., to narrow the gap between academia and industry.
6. Handle advanced instruments to enhance technical talent.
7. Gain confidence in modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
8. Accustom Work on different software/s (tools) to simulate, analyse and authenticate the output to interpret and conclude.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss research methodology and the technique of defining a research problem	2
CO2	Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review	2
CO3	Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.	2
CO4	Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports	2
CO5	Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR	2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs (indicative only)

	PO1	PO2	PO3	PO4	PO5
CO1	**1**	**1**	**1**	**3**	**1**
CO2	**1**	**1**	**2**	**3**	**1**
CO3	**1**	**1**	**3**	**3**	**3**
CO4	**1**	**1**	**2**	**3**	**3**
CO5	**1**	**1**	**3**	**2**	**3**

Note : High - 1, Medium – 2, and Low – 3

INSTRUMENTATION AND EXPERIMENTAL STRESS ANALYSIS LABORATORY			
Course Code	**22MDEL17**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Total Hours of Pedagogy	15 + 10 -12 Laboratory Sessions	Total Marks	100
Credits	2	Exam Hours	3

Course objectives:

The students

- To demonstrate the working principle of different measuring instruments
- To demonstrate the methodology for the calibration of instruments
- To educate the students about the various vibration measuring equipment and non-destructive devices
- To explain the application of photo elastic methods to stress detemination

Sl.NO	EXPERIMENTS
1	Measurement of strain by using strain gauges
2	Calibration of Rotameter themocouples
3	Experiments with piezo-electric pick-up, Inductive pick-ups. Determination of characteristics - Displacement, Velocity and Acceleration.
4	Ultrasonic flaw detector
5	Experiments on photo-elastic bench (Plain polariscope, Circular polariscope).

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Model simple to complicated kinematic systems independently
- Analyse and interpret the commonly occurring kinematic systems in a commercial software
- Verify the results of simulations of a commercial software with Analytical Methods

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8^{th} week of the semester and the second test shall be conducted after the 14^{th} week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute; examiners are appointed by the University.

- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
- Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. Experimental Methods in Fluid Mechanics, IIT Guwahati, (https://nptel.ac.in/courses/112103290)
2. Overview of Experimental Stress Analysis (https://nptel.ac.in/courses/112106068)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M. Tech., Design Engineering. (MDE)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2022
M. Tech., Design Engineering (MDE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	PCC	22MDE21	Reliability Engineering	02	00	02	03	50	50	100	3
2	IPCC	22MDE/MEA/MMD22	Advanced Finite Element Methods and Applications	03	02	00	03	50	50	100	4
3	PEC	22MDE23x	Professional Elective 1	02	00	02	03	50	50	100	3
4	PEC	22MDE24x	Professional Elective 2	02	00	02	03	50	50	100	3
5	MPS	22MDE25	Mini Project with Seminar	00	04	02	--	100	--	100	3
6	PCCL	22MDEL26	Finite Element Laboratory	01	02	00	03	50	50	100	02
7	AUD/ AEC	22AUD27	Suggested ONLINE courses	Classes and evaluation procedures are as per the policy of the online course providers.							PP
TOTAL				**10**	**08**	**08**	**15**	**350**	**250**	**600**	**18**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Professional Elective 1		**Professional Elective 2**	
Course Code under 22MDE24X	**Course title**	**Course Codeunder 22MDE25X**	**Course title**
22MDE/MEA/MMD/MST	Optimization Techniques	22MDE/MEA/MMD24	Mechatronics System Design
22MDE/MEA/MMD232	Fracture Mechanics	22MDE/MEA/MMD24	Mechanical Behaviour of Materials
22MDE/MEA/MMD233	Computer Aided Geometric Design	22MDE/MEA/MMD24	Basics of Machine Learning
22MDE/MEA/MMD234	Fatigue and Failure Analysis	22MDE/MEA/MMD244	Design for Manufacturing and Assembly
22MDE/MEA/MMD235	Stress Analysis	22MPD/MAU/MDE/M	Industry 4.0

Note

1 Mini Project with Seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.
CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question and Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester. There is no SEE for this course.

2. Internship: All the students shall have to undergo a mandatory internship of **06 weeks** during the vacation of II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. The internship shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in the internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Program Outcomes (POs)

1. **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.

2. **PO2:** An ability to write and present a substantial technical report/document.

3. **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.
4. **PO4**: Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.
5. **PO5**: Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions

II SEMESTER

RELIABILITY ENGINEERING			
Course Code	**22MDE21**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To explain the concept of reliability and its applications
2. To discuss the use of Reliability testing

MODULE-1(5 Hours)

Introduction: Concepts of quality and reliability, a brief history, terms, definitions, reliability function, MTTF, Hazard rate function, bath tub curve, conditional reliability.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Constant failure rate models: Exponential reliability, failure modes, failure modes with exponential distribution, applications, two parameter exponential distribution, Poisson process. **Time dependent failure models:** Weibull distribution, burn-in screening for Weibull, three parameter Weibull distribution, Normal and Lognormal distributions

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Reliability of systems: Series, parallel configurations, combined systems, k-out-of-n systems, complex configurations, common failure modes, minimal cuts and minimal paths.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

State dependent systems: Markov analysis, load sharing, standby systems, degraded systems

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Design for reliability: Reliability specification, Lifecycle costs, reliability allocation, design methods, failure analysis, FTA.
Reliability testing: Life testing, burn-in testing, acceptance testing-binomial acceptance testing.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Charles E Ebeling, Introduction to Reliability and Maintenance engineering, Tata McGraw hill, India.
2. E.E. Lewis , Introduction to Reliability Engineering, John Wiley & Sons, New York
3. S. S. Rao, Reliability based design, McGraw-Hill, New York

Web links and Video Lectures (e-Resources):

1. Reliability Engineering, IISc Bangalore (https://nptel.ac.in/courses/105108128)

Skill Development Activities Suggested

1. Exercise on reliability using MATLAB/SCILAB

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Discuss the various concepts related to reliability, probability distribution.	2
CO2	Apply the reliability techniques for industrial applications	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**		**1**	**1**	**2**
CO2	**3**		**1**	**3**	**2**

Note : High - 1, Medium – 2, and Low – 3

ADVANCED FINITE ELEMENT METHODS AND APPLICATIONS			
Course Code	**22MDE22**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	03:02:00	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

1. Introduce basic aspects of finite element technology, including domain discretization, polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems.
2. Discuss the use of finite element methods in engineering problem-solving drawing from applications in solid mechanics and other engineering Domains.
3. Familiarize students with professional-level finite element software.
4. To define, derive and assemble stiffness matrices for spring element, truss element, beam elements, Plane Stress element.
5. To be familiar with the idea of Isoparametric formulation for various FE Elements
6. FE Formulation of Axisymmetric and Solid Elements.

MODULE-1 (8 Hours)

Mathematical Preliminaries: Principle of Virtual Work, General steps of the Finite Element Method.

Introduction to the Stiffness (Displacement) Method: Definition of the Stiffness Matrix, Derivation of the Stiffness Matrix for a Spring Element, Example of a Spring Assemblage, Assembling the total Stiffness Matrix by Superposition Method, Boundary Conditions, Potential Energy Approach to Derive Spring Element Equations.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Development of Truss Equations: Derivation of the Stiffness Matrix for a Bar Element in Local Coordinates, Selecting a Displacement Function, Transformation of vectors in Two Dimensions, Global Stiffness Matrix for Bar Arbitrarily Oriented in the Plane, Computation of Stress for a Bar in the x – y Plane, Solution of a Plane Truss, Transformation Matrix and Stiffness Matrix for a Bar in three-Dimensional space, Use of symmetry in Structures, Inclined Supports, Potential Energy Approach to Derive Bar Element Equations, Galerkin's Residual Method and its Use to Derive the One-Dimensional Bar Element Equations, Other Residual Methods and their application to a One-Dimensional bar problem.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3 (8 Hours)

Development of Beam Equations: Beam stiffness, Example of Assemblage of Beam Stiffness Matrices, Examples of Beam analysis Using the Direct stiffness Method, Distributed Loading, Beam Element with Nodal Hinge, Potential Energy Approach to Derive Beam Element Equations, Galerkin's Method for Deriving Beam Element Equations.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4 (8 Hours)

Development of the Plane Stress and Plane Strain Stiffness Equations: Basic Concepts of Plane Stress and Plane Strain, Derivation of the Constant-Strain triangular Element Stiffness Matrix and Equations, Treatment of body and Surface Forces, Explicit Expression for the Constant-Strain Triangle Stiffness Matrix, Finite Element Solution of a Plane Stress Problem, Rectangular Plane Element (bilinear rectangle, Q4).

Development of the Linear Strain Triangle Equations: Derivation of the Linear-Strain Triangular Element Stiffness Matrix and Equations, Example LST Stiffness Determination, Comparison of Elements.

Axisymmetric Elements: Derivation of the stiffness Matrix, Solution of an Axisymmetric pressure vessel.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5 (8 Hours)

Isoparametric Formulation: Isoparametric Formulation of the Bar Element Stiffness Matrix, Isoparametric Formulation of the plane Quadrilateral (Q4) Element Stiffness Matrix, Newton-Cotes and Gaussian Quadrature, Evaluation of the Stiffness Matrix and Stress Matrix by Gaussian Quadrature, Higher-Order Shape Functions (including Q6, Q8,Q9, and Q12 Elements).

Three-Dimensional Stress Analysis: Three-Dimensional Stress and Strain, Tetrahedral element, Isoparametric Formulation and Hexahedral element.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

PRACTICAL COMPONENT OF IPCC

Sl.NO.	Experiments
1	Solve (with MATLAB), the ODE using the weak formulation (FEM/MATLAB): $a\frac{d^2u}{dx^2} + b\frac{du}{dx} + cu = f(x),\ 0 < x < L\ with\ Boundary\ Conditions: u(0) = 0\ and\ u(L) = 0$ take a=1, b=-3, c=2 and f(x)=1. Take domain size as 1 (i.e. L=1) and take Five linear elements of equal size.
2	Solve (with MATLAB), the ODE using the weak formulation (FEM/MATLAB): $a\frac{d^2u}{dx^2} + b\frac{du}{dx} + cu = f(x),\ 0 < x < L\ with\ Boundary\ Conditions: u(0) = 0\ and\ \frac{du}{dx}(1) = 0$ take a=1,b=-3, c=2 and f(x)=1. Take domain size as 1(i.e. L=1) and take Five linear elements of equal size.

3	Solve using MATLAB, the Laplace equation representing two dimensional steady-state problems using both linear triangle elements with the given boundary conditions: $$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0 \ \ for\ 0 < x < 5\ and\ 0 < y < 10.$$ The boundary conditions are u(x, 0) =0 for 0<x<5, u(0,y)=0 for 0<y<10, u(x,10)=100sin(ϖx/10) for 0<x<5, and $\frac{\partial u(5,y)}{\partial x}$ =0 for 0<y<10.
4	Solve the problem 3 using the bilinear rectangular elements with other conditions remaining same.
5	Write a MATLAB program to Use Gauss-Legendre quadrature for integration of $f(x,y) = 1 + 4xy - 3x^2y^2 + x^4y^6$ over the domain -1<x<1 and -1<y<1. Use 3-point quadrature rule along the x-axis and 4-point quadrature rule along y-axis.
6	Determine the natural frequency of a free bar (Fixed at one end and free at other) using the finite element method. The bar has Young's Modulus of 200 GPa, Cross-sectional area of 0.001 m^2 , Density of 7860 Kg/m^3 and Length of 4 m.
7	Write a MATLAB program to perform stress analysis of a cantilever beam subjected to end load using two dimensional Isoparametric elements assuming plane stress condition. Model the beam using ten four-node quadrilateral elements.
8	Write a generalised MATLAB Code that can solve any two dimensional truss structure to find member forces.
9	Make a report of available 1D, 2D and 3D Elements in a commercial FE Software.
10	Make a report of the practical aspects to be considered while generating a mesh in commercial software.
Demonstration Experiments	
11	Solve a problem of a Cantilever beam subjected to end point load in a commercial software to find out its displacements and stresses
12	Write a script in commercial software to automate the above problem for various dimensions and material properties.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

- Two Tests each of **20 Marks**
- Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
- Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.

The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

- The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

num marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the mponent and 10 (50% of maximum marks -20) in the practical component. The laboratory component CC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all should not be more than the 20 marks.

be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the ks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks rse(CIE+SEE)

Suggested Learning Resources:

Books

1. Daryl L. Logan, "A First Course in the Finite Element Method", 6th Edition, Cengage Learning, 2017.
2. Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", John Wiley & Sons, 2007
3. J. N. Reddy, "An Introduction to the Finite Element Method", 3rd Edition, Mc-Graw Hill, 2006
4. Ferreira, Antonio & Fantuzzi, Nicholas., "MATLAB Codes for Finite Element Analysis: Solids and Structures", Springer, 2009.

Web links and Video Lectures (e-Resources):

1. NOC: Finite Element Method: Variational Methods to Computer Programming, IIT Guwahati (https://nptel.ac.in/courses/112103295)
2. NOC:Basics of Finite Element Analysis - II, IIT Kanpur (https://nptel.ac.in/courses/112104205)
3. Abaqus FEA Tutorial Videos (https://www.youtube.com/user/AbaqusPython)

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Write MATLAB/ SCILAB programs to Analyse the 1D,2D, and 3D Finite Elements.
2. Practice the Modelling, Meshing, and Analysis of simple structures in commercial software and compare the results with closed form solutions.
3. Take an open source FE Software, Compile, and generate an executable file.
4. Understand and summarise the format of the input ASCII files generated by commercial meshing software for any well know FE Solver.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the Basis of formulation of Finite Element Methods	2
CO2	Formulate the complete FE Formulation for 1D, 2D, and 3D Elements	3
CO3	Evaluate various boundary conditions in the FE Application	5
CO4	Write a computer program to analyse a simple Truss structure	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**1**	**1**	**3**	**3**
CO2	**3**	**2**	**1**	**3**	**3**
CO3	**3**	**3**	**1**	**3**	**2**
CO4	**1**	**3**	**1**	**1**	**1**

Note : High - 1, Medium – 2, and Low – 3

Professional Elective 1

OPTIMIZATION TECHNIQUES			
Course Code	**22MDE/MEA/MMD/MST231**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 +10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Enumerate the fundamental knowledge of Linear Programming and Dynamic Programming problems.
2. Learn classical optimization techniques and numerical methods of optimization.
3. Know the basics of different evolutionary algorithms.
4. Explain Integer programming techniques and apply different optimization techniques to solve various models arising from engineering areas

MODULE-1 (5 Hours)

Liner Programming (LP): Revised Simplex Method, Duel simplex Method, Sensitivity Analysis

Dynamic Programming (DP): Multistage decision processes. Concepts of sub optimization, Recursive Relation-calculus method, tabular method, LP as a case of D.P

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2 (5 Hours)

Classical Optimization Techniques: Single variable optimization without constraints,Multi variable optimization without constraints, multivariable optimization with constraints method of Lagrange multipliers, Kuhn-Tucker conditions.

Numerical Methods For Optimization: Nelder Mead's Simplex search method, Gradient of a function, Steepest descent method, Newton's method

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3 (5 Hours)

Modern methods of optimization:

Genetic Algorithm (GA): Differences and similarities between conventional and evolutionary algorithms, working principle, Genetic Operators- reproduction, crossover, mutation.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4 (5 Hours)

Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, Random population generation.

Fuzzy Systems: Fuzzy set Theory, Optimization of Fuzzy systems

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5 (5 Hours)

Integer Programming: Graphical Representation, Gomory's Cutting Plane Method, Balas' Algorithm for Zero–One Programming, Branch-and-Bound Method.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Singiresu S. Rao," Engineering Optimization Theory and Practice", 4th Edition, John Wiley, 2009
2. Kalyanmoy Deb,Optimization forEngineering Design Algorithms and Examples,2nd Edition, PHI Learning Private Limited, New Delhi, 2012
3. David E. Goldberg,"Genetic Algorithms in Search, Optimization and Machine Learning", Addison-Wesley Longman Publishing Co., Inc, 1989
4. Frederick Hillier and Gerald Lieberman, "Introduction to Operations Research", 11th Edition, Tata Mc Graw Hill, 2021,
5. Jasbir S. Arora, "Introduction to Optimum Design", McGraw - Hill College, 1988

Web links and Video Lectures (e-Resources):

- Optimization Toolbox (https://in.mathworks.com/products/optimization.html)
- S.N. Sivanandam, S.N. Deepa ,Principles of Soft Computing, 2nd Edition ,2011
- Principle of Soft computing (https://archive.nptel.ac.in/courses/106/105/106105173/)

Skill Development Activities Suggested

1. One or two exercises of Optimization using MATLAB/Python.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Apply the fundamental knowledge of Linear Programming and Dynamic Programming problems.	3
CO2	Use classical optimization techniques and numerical methods of optimization.	3
CO3	Enumerate fundamentals of Integer programming technique and apply GA and Fuzzy techniques to solve various problems in engineering areas.	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**-**	**1**	**1**	**1**
CO2	**3**	**-**	**1**	**3**	**1**
CO3	**3**	**-**	**1**	**3**	**2**

Note : High - 1, Medium – 2, and Low – 3

FRACTURE MECHANICS			
Course Code	**22MDE/MEA/MMD232**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To discuss presence of various flaws in a body
2. To study different methods of identifying them non-destructively
3. To study the linear elastic fracture parameters such as Energy Release Rate and Stress Intensity Factor.
4. Discuss the elasto-plastic fracture parameters such as CTOD and J-Integral

MODULE-1(8 Hours)

Introduction to Fracture Mechanics: Kinds of Failure, Historical Aspects, Brittle and Ductile Fracture, Modes of Fracture Failure, How Potent is a Crack?, Point of View, Damage Tolerance.

Crack Detection through Non-Destructive Testing: Examination through Human Senses, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging, Magnetic Particle Inspection.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Energy Release Rate: Griffith's Dilemma, Surface Energy, Griffith's Realization, Griffith's Analysis, Energy Release Rate, Energy Release Rate of DCB Specimen, Anelastic Deformation at Crack-tip, Crack Resistance, Stable and Unstable Crack Growth, R-curve for Brittle Cracks, Thin Plate vs Thick Plate, Critical Energy Release Rate.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Stress Intensity Factor: Stress and Displacement Fields in Isotropic Elastic Materials ,Stress Intensity Factor,Background for Mathematical Analysis,Westergaard's Approach-Model (Opening Mode),Mode II (Sliding Mode),Mode III (Tearing Mode).

SIF of More Complex Cases: Other Applications of Westergaard Approach, Application of the Principle of Superposition, Crack in a Plate of Finite Dimensions, Edge Cracks, Embedded Cracks, The Relation between GI and KI, Critical Stress Intensity Factor.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Anelastic Deformation at the Crack Tip:Further Investigation at the Crack Tip Approximate Shape and Size of the Plastic Zone,Effective Crack Length-Approximate Approach,The Irwin Plastic Zone Correction,Plastic Zone Size through the Dugdale Approach. Effect of Plate Thickness.

J-Integral: Relevance and Scope,Definition of the J-Integral,Path Independence,Stress-Strain Relation, Further Discussion on J-Integral-From a Designer's Point of View,Experiments to Determine the CriticalJ-Integral,Comments on the Numerical Evaluation ofJ-Integral,Predicting Safety or Failure,Comments on the Experimental Determination of the Toughness of Ductile Materials.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

Crack Tip Opening Displacement: Introduction,Relationship between CTOD, K_I and G_I for Small Scale Yielding,Equivalence between CTOD andJ.

Test Methods :K_{IC}-Test Technique, Test Methods to Determine J_{IC}, Test Methods to Determine G_{IC} and G_{IIC},DeterminationofCriticalCTOD

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks**or**oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

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Suggested Learning Resources:

Books

1. Prashant Kumar, "Elements Of Fracture Mechanics", Tata McGraw-Hill Publishing Company Limited, 2009
2. T. L. Anderson," Fracture Mechanics: Fundamentals and Applications",3rd Edition. CRC Press, 2005

Web links and Video Lectures (e-Resources):

1. Introduction To Fracture Mechanics (https://ocw.mit.edu/courses/3-11-mechanics-of-materials-fall-1999/resources/mit3_11f99_frac/)
2. Engineering Fracture Mechanics NPTEL (https://archive.nptel.ac.in/courses/112/106/112106065/

Skill Development Activities Suggested

- Learn to use fracture mechanics of software such as NASGRO (https://www.swri.org/consortia/nasgro), AFGROW (https://www.afgrow.net/), FRANC3D (https://franc3d.in/)
- Study the ASTM Standards used to find various Fracture Parameters
- Write code to simulate the fatigue growthby fracture as in NASGRO.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Compute elastic stress analysis of cracked bodies subjected to various static loading and determine the expression for displacement, stress and strain.	3
CO2	Determine the expression for stress intensity factors for mode I mode II and Mode III loading.	2
CO3	Evaluate fracture Toughness for metallic materials according to ASTM standard testmethods.	3
CO4	Identify the elastic plastic fracture behaviour and fracture toughness values in terms R, J, and CTOD.	2
CO5	Outline fatigue crack growth behaviour and crack growth laws and design mechanical members and develop fracture control plan.	5

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**				**1**
CO2	**1**				**3**
CO3	**1**				**1**
CO4	**1**				**1**
CO5	**1**				**1**

Note : High - 1, Medium – 2, and Low – 3

COMPUTER AIDED GEOMETRIC DESIGN			
Course Code	**22MDE/MEA/MMD233**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	02:00:02	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To discuss the Mathematical techniques for the definition and manipulation of curves and surfaces.
2. To explore the various curves used in CAD.

MODULE-1(5 Hours)

Transformations of the Plane: Introduction, Translations, Scaling about the Origin, Reflections, Rotation about the Origin, Shears, Concatenation of Transformations,Applications.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Homogeneous Coordinates and Transformations of the Plane: Introduction, Points at Infinity, Visualization of the Projective Plane, Transformations in Homogeneous Coordinates, Concatenation of Transformations , Applications, Point and Line Geometry in Homogeneous Coordinates.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Homogeneous Coordinates and Transformations of Space: Homogeneous Coordinates, Transformations of Space, Applications, Geometric Methods for Lines and Planes in Space, Quaternions**.**

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Projections and the Viewing Pipeline: Introduction, Projections of the Plane , Projections of Three-dimensional Space, The View plane Coordinate Mapping, The Viewing Pipeline , Classification of Projections.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Curves: Introduction, Curve Rendering, Parametric Curves, Arc length and Reparametrization, Application: Numerical Controlled Machining and Offsets, Conics, Conics in Space, Applications of Conics.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks**

to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Duncan Marsh, Applied Geometry for Computer Graphics and CAD, 2nd Edition, Springer-Verlag London Limited 2005
2. Gerald Farin, Curves and Surfaces for Computer Aided Geometric Design, A Practical Guide. Morgan Kaufmann, 5th ed., ISBN 1-55860-737-4, 2002.
3. Nicholas M. Patrikalakis and Takashi Maekawa, Shape Interrogation for Computer-Aided Design and Manufacturing, Springer 2001.

Web links and Video Lectures (e-Resources):

1. https://class236716.cs.technion.ac.il/lectures/
2. https://cs.ucdavis.edu/schedules-classes/ecs-278-computer-aided-geometric-design

Skill Development Activities Suggested

1. Writing MATLAB code to represent curves and surfaces
2. Codes to simulate geometric transformations
3. Code and operate the Bezier and other similar curves

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Perform the basic transformations of geometrical objects	3
CO2	Operate in the homogeneous coordinate system	3
CO3	Define, Code and Use various curves	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5		

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**		**1**	**3**	
CO2			**1**	**3**	
CO3	**3**		**2**	**3**	

Note : High - 1, Medium – 2, and Low – 3

FATIGUE AND FAILURE ANALYSIS			
Course Code	**22MDE/MEA/MMD234**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25+10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Introduce basic aspects of Fatigue and Failure.
2. Discuss the availability of various fatigue analysis methods that are used by professional.
3. Know the modifications required in case of mean stress and notches
4. To understand various cycle counting methods used in industries and in commercial software.
5. Familiarize with the fatigue of spot welds.

MODULE-1(5 Hours)

Fatigue Damage Theories: Fatigue damage mechanism, Cumulative damage models,Linear damage models,Double linear damage rule by Manson and Halford.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Stress-Based Fatigue Analysis and Design: Introduction,The stress-life (S-N) and fatigue limit testing, Estimated SN curve of a component based on ultimate tensile strength, Notch effect, Mean stress effect,Combined proportional loads.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(6 Hours)

Strain-Based Fatigue Analysis and Design: Introduction, Experimental test program, Analysis of monotonic and cyclic stress–strain behaviour of materials,Mean stress correction methods,Estimation of cyclic and fatigue properties,Notch analysis.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Cycle Counting Techniques: One-parameter cycle counting methods,Two-parameter cycle counting methods,Four-Point Cycle Counting Method,Reconstruction of a load-time history.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(4 Hours)

Fatigue of Spot Welds: Introduction, WeldSpecimen Testing for Fatigue life calculation.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Yung-Li Lee, Jwo Pan, Richard Hathaway, Mark Barkey." Fatigue Testing and Analysis : Theory and Practice", Elsevier, 2005.
2. Julie A. Bannantine, Jess J. Comer, James L. Handrock,"Fundamentals of Metal Fatigue Analysis", Prentice Hall, 1990.
3. Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs,"Metal Fatigue in Engineering", John Wiley & Sons, 2000.
4. Anderson T L, "Fracture Mechanics: Fundamentals and Applications", 4th Edition, CRC Press, 2017.
5. ASTM Standard E399, "Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness KIc of Metallic Materials," ASTM International.
6. MSC Fatigue 2021.4 (Theory Guide): (https://www.mscsoftware.com)

Web links and Video Lectures (e-Resources):

1. Practical Fatigue Theory (Online) (https://www.ncode.com/services/training-courses/practical-fatigue-theory-ncode-training-online)
2. Constant Amplitude Stress-Life Analysis ,(https://www.efatigue.com/constantamplitude/stresslife/#a)
3. Fatigue & Fracture Mechanics in FEA (https://www.nafems.org/training/e-learning/fatigue-fracture-fea/)
4. What is Fatigue Analysis? | MSC Nastran (https://simulatemore.mscsoftware.com/what-is-fatigue-analysis-msc-nastran/)

Skill Development Activities Suggested

1. Run a MSC NASTRAN Fatigue Analysis
2. Try A sample Problem of Spot Welding in MSC Fatigue
3. Explore various Fatigue and Fracture software.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Correctly predict Fatigue life of metal components using Stress and Strain life Methods.	3
CO2	Analyse the situation to apply appropriate fatigue failure method	3
CO3	Identify and describe the basic fatigue mechanisms.	2
CO4	Demonstrate the application of the methods for fatigue life of spot Weld	3

Program Outcome of this course

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**				**1**
CO2	**3**				**1**
CO3	**3**				**1**
CO4	**3**				**3**

Note : High - 1, Medium – 2, and Low – 3

STRESS ANALYSIS			
Course Code	**22MDE/MEA/MMD235**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand concept of stress and strain analysis at a point.
2. To understand the various facets of elasticity problems
3. To study methods of analysis for beams stresses and strains
4. To study different techniques of stress analysis under energy methods

MODULE-1(5 Hours)

Analysis of Stress : Introduction , Analysis and Design, Conditions of Equilibrium , Definition and Components of Stress, Internal Force Resultant and Stress Relations, Stresses on Inclined Sections, Variation of Stress within a Body, Plane-Stress Transformation, Principal Stresses and Maximum In-Plane Shear Stress, Mohr's Circle for Two-Dimensional Stress, Three-Dimensional Stress Transformation, Principal Stresses in Three Dimensions, Normal and Shear Stresses on an Oblique Plane, Mohr's Circles in Three Dimensions, Boundary Conditions in Terms of Surface Forces.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Strain and Material Properties: Introduction, Deformation, Strain Defined, Equations of Compatibility, State of Strain at a Point, Engineering Materials, General Properties of Some Common Materials, Stress-Strain Diagrams, Elastic versus Plastic Behavior, Hooke's Law and Poisson's Ratio, Generalized Hooke's Law, Orthotropic Materials, Measurement of Strain: Strain Gage, Strain Energy, Strain Energy in Common Structural Members, Components of Strain Energy, Saint-Venant's Principle.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Problems in Elasticity: Introduction, Fundamental Principles of Analysis, Plane Strain Problems, Plane Stress Problems, Comparison of Two-Dimensional Isotropic Problems, Airy's Stress Function, Solution of Elasticity Problems, Thermal Stresses.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Failure Criteria: Static Loading: Failure by Yielding, Failure by Fracture, Yield and Fracture Criteria, Maximum Shearing Stress Theory, Maximum Distortion Energy Theory, Octahedral Shearing Stress Theory, Comparison of the Yielding Theories, Maximum Principal Stress Theory, Mohr's Theory, Coulomb–Mohr Theory.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Bending of Beams: Exact Solutions - Pure Bending of Beams of Symmetrical Cross Section, Pure Bending of Beams of Asymmetrical Cross Section, Bending of a Cantilever of Narrow Section, Bending of a Simply Supported Narrow Beam, Approximate Solutions - Elementary Theory of Bending, Normal and Shear Stresses, Effect of Transverse Normal Stress, Composite Beams, Shear Center.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Ansel C. Ugural, Saul K. Fenster, "Advanced Mechanics of Materials and Applied Elasticity", 6th Edition, Pearson Education, 2020
2. S.P. Timoshenko and J.N. Goodier, "Theory of Elasticity," McGraw-Hill, Third Ed., New York, (1970)
3. Arthur P. Boresi, Richard J. Schmidt,"Advanced Mechanics of Materials", 6th Edition. Wiley, 2002

Web links and Video Lectures (e-Resources):

1. Strength of Materials :https://nptel.ac.in/courses/112107146
2. Advanced Strength of Materials, https://nptel.ac.in/courses/112101095
3. Mechanics of Solids :https://www.youtube.com/watch?v=whB7IX3NQpg&list=PL4C9BB8DDD5D888A6

Skill Development Activities Suggested

1. Write a small application to display Mohr's circle for a given stress condition and to find principal stresses
2. Develop an application which can solve the displacement and stress of a beam for any end condition

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Determine stress distribution along a component under different loading conditions.	3
CO2	Solve real time problems subjected under bending.	3
CO3	Compute stresses developed in a member subjected to Torque	2
CO4	Apply some of basic energy methods to solve elasticity problems	3

Program Outcome of this course

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**2**		**1**	**3**	**3**
CO2	**1**	**3**	**1**	**2**	**1**
CO3	**3**		**1**	**3**	**1**

Note : High - 1, Medium – 2, and Low – 3

Professional Elective 2

MECHATRONICS SYSTEM DESIGN			
Course Code	**22MDE/MEA/MMD241**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To educate the student regarding integration of mechanical electronics electrical and computer systems in the design of CNC machine tools
2. To provide students with an understanding of the mechatronics design process actuators, sensors transducers signal conditioning, MEMS and Microsystems
3. To introduce Advanced Application in mechatronics

MODULE-1

Definition and Introduction to Mechatronic System, Modeling&Simulation of Physical systems, Overview of Mechatronic Products and their functioning, measurement systems, Control Systems, simple Controllers, Study of Sensors and Transducers, Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2

Electrical Actuation Systems: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors System Models, Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3

Signal Conditioning: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation. MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4

System model, Engineering systems, rotational-translational system, electromechanical systems, Hydraulic-mechanical systems. Dynamics responses of systems, modelling dynamic systems, first order system, second order system, performance measures for second – order systems. systems transfer functions, the transfer function, first order systems second order systems, system in series,

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5

Microprocessors, control, microprocessor systems, microcontrollers, applications, Assembly language, languages, instruction sets, assembly language programs, C languages-Why C, Program structure, branched and loops, arrays, pointers program developments.	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks**or**oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

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Suggested Learning Resources:

Books

1. W. Bolton, "Mechatronics" - Addison Wesley Longman Publication, 1999
2. HSU "MEMS and Microsystems design and manufacture"- Tata McGraw-Hill Education, 2002
3. Kamm, "Understanding Electro-Mechanical Engineering an Introduction to Mechatronics"- IEEE Press, 1 edition ,1996
4. Shetty and Kolk "Mechatronics System Design"- Cengage Learning, 2010
5. Mahalik "Mechatronics"- Tata McGraw-Hill Education, 2003

Web links and Video Lectures (e-Resources):

1. Design of Mechatronic Systems (https://onlinecourses.nptel.ac.in/noc21_me129/preview)
2. Virtual Laboratory, Ministry of Education, Government of India. (https://www.vlab.co.in/broad-area-mechanical-engineering)

Skill Development Activities Suggested

1. Try exploring various laboratories provided in Virtual Laboratory, Ministry of Education, Government of India.
2. Write few assembly programmes targeted at any of the Intel microprocessors.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Describe mechatronic systems and overview of control systems & actuators	2
CO2	Identify and describe the different types of actuators used in mechatronics systems	2
CO3	Differentiate between various sensors, transducers and actuators and their application	4
CO4	Identify and describe the different types of speed and position-feedback devices	2
CO5	Relate various signal conditioning units, amplifiers, logic gates and their role in programmable logic controllers	4
CO6	Discuss the importance of feedback in controlling physical systems with the use of examples	2
CO7	Identify and describe the types of controllers used in mechatronics systems	2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COS and POs

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**1**	**3**	**2**
CO2	**3**	**3**	**1**	**3**	**2**
CO3	**3**	**3**	**1**	**2**	**2**
CO4	**3**	**3**	**1**	**3**	**2**
CO5	**3**	**3**	**1**	**3**	**1**
CO6	**3**	**3**	**1**	**2**	**2**
CO7	**2**	**3**	**1**	**2**	**2**

Note : High - 1, Medium – 2, and Low – 3

MECHANICAL BEHAVIOUR OF MATERIALS			
Course Code	**22MDE/MEA/MMD242**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To familiarize the concept of deformation mechanisms in single crystal and polycrystalline materials.
2. To study strengthening mechanisms and mechanics of fracture in ductile and brittle materials
3. To study the fatigue and creep properties of materials under various conditions
4. To familiarize the various characterization techniques used to probe mechanical properties.

MODULE-1(5 Hours)

Plastic Deformation: Concepts of crystals, Plastic deformation by slip and twinning, Slip systems in FCC, BCC and HCP lattices, Critical resolved shear stress for slip, Theoretical shear strength of solids, Stacking faults and deformation bands.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Dislocation Theory : Observation of dislocations, Climb and cross slip, Dislocations in FCC and HCP lattice, Partial dislocations, Stress fields and energies of dislocations, Forces between dislocations, Interaction of dislocations, Dislocation sources and their multiplications.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(6 Hours)

Strengthening Mechanisms: Strengthening from grain boundaries, Grain size measurements, Yield point phenomenon, Strain aging, Solid solution strengthening, Strengthening from fine particles, Fiber strengthening, Cold working and strainhardening, Annealing of cold worked metal.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Creep and Stress Rupture: Creep curve, Stress rupture test, Mechanism of creep deformation, Activation energy for steady state creep, Superplasticity, Fracture at elevated temperature, Creep resistant alloys, Creep under combined stresses.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(4 Hours)

The Tension Test: Stress-strain curves, Instability in tension, Ductility measurement, Effect of strain rate, temperature and testing machine on flow properties, Stress relaxation testing, Notch tensile test, Anisotropy of tensile properties.

The Hardness Test: Brinnel, Rockwell and Vickers hardness, flow of metal under the indenter, relationship between hardness and flow curve, micro hardness testing, Hardness at elevated temperatures.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Dieter M. George, Mechanical Metallurgy, McGraw- Hill Inc., 2001.
2. Richard W Hertzberg Deformation and fracture mechanics, John Wiley & Sons
3. Reed Hill and Robert E, Physical Metallurgy Principles, East West Press
4. Hyden W. M. Structure and properties of Materials, Vol. 3, McGraw Hill

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Web links and Video Lectures (e-Resources):

1. Mechanical Behavior of Materials https://onlinecourses.nptel.ac.in/noc21_mm27/preview
2. Mechanical Behaviour of Materials https://onlinecourses.nptel.ac.in/noc22_mm04/preview

Skill Development Activities Suggested

1. Use a strain gage setup to estimate the strains at a surface point of a plate subjected to tensile loading
2. Identify and list the values of SN curves for various alloys of Steel and Aluminium

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Explain the effect of dislocations and their interaction on the material strength	2
CO2	Apply the concept of fracture toughness to material failure	2
CO3	Carry out the Tensile test for a steel specimen	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**		**1**	**3**	**1**
CO2	**3**		**1**	**2**	
CO3	**1**		**1**	**3**	**1**

Note : High - 1, Medium – 2, and Low – 3

BASICS OF MACHINE LEARNING			
Course Code	**22MD243**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand the basic theory underlying machine learning.
2. To be able to formulate machine learning problems corresponding to different applications.
3. To understand a range of machine learning algorithms along with their strengths and weaknesses.
4. To be able to apply machine learning algorithms to solve problems of moderate complexity.
5. To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

MODULE-1(5 Hours)

Introduction to Machine Learning

Introduction, Components of Learning, Learning Models, Geometric Models, Probabilistic Models, Logic Models, Grouping and Grading, Designing a Learning System, Types of Learning, Supervised, Unsupervised, Reinforcement, Perspectives and Issues, Version Spaces, PAC Learning, VC Dimension.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Supervised and Unsupervised Learning

Decision Trees: ID3, Classification and Regression Trees, Regression: Linear Regression, Multiple Linear Regression, Logistic Regression, Neural Networks: Introduction, Perception, Multilayer Perception, Support Vector Machines: Linear and Non-Linear, Kernel Functions, K Nearest Neighbors. Introduction to clustering, K-means clustering, K-Mode Clustering.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Ensemble and Probabilistic Learning

Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: Random Forest Trees,
Boosting: Adaboost, Stacking.
Gaussian mixture models - The Expectation-Maximization (EM) Algorithm, Information Criteria, **Nearestneighbour methods** - Nearest Neighbour Smoothing, Efficient Distance Computations: the KD-Tree, Distance Measures.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Reinforcement Learning and Evaluating Hypotheses

Introduction, Learning Task, Q Learning, Non deterministic Rewards and actions, temporal-difference learning, Relationship to Dynamic Programming, Active reinforcement learning, Generalization in reinforcement learning. Motivation, Basics of Sampling Theory: Error Estimation and Estimating Binomial Proportions, The

Binomial Distribution, Estimators, Bias, and Variance

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Genetic Algorithms: Motivation, Genetic Algorithms: Representing Hypotheses, Genetic Operator, Fitness Function and Selection, An Illustrative Example, Hypothesis Space Search, Genetic Programming, Models of Evolution and Learning: Lamarkian Evolution, Baldwin Effect, Parallelizing Genetic Algorithms.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks**or**oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Tom M. Mitchell , "Machine learning", McGraw Hill 1997
2. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3. RajjanShinghal, "Pattern Recognition", Oxford Press, 2006.
4. EthemAlpaydin, "Introduction to machine learning", PHI learning, 2008.
5. Hastie, Tibshirani, Friedman, "The Elements of Statistical Learning", Springer 2001.
6. R.O. Duda, P.E. Hart and D.G. Stork, Pattern Classification, Wiley-Interscience, 2nd Edition, 2000.
7. T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, 2nd Edition, 2009

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars

Activities

- Mini project on live working model/ Problems.
- Seminar
- Assignment

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Choose the learning techniques with this basic knowledge	2
CO2	Apply effectively genetic algorithms for appropriate applications	3
CO3	Apply Bayesian techniques and derive effectively learning rules.	3
CO4	Choose and differentiate Clustering & Unsupervised Learning and Language Learning	2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
4	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5
5		

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1			**1**	**3**	**1**
CO2	**3**		**1**	**2**	**1**
CO3	**3**		**1**	**2**	**1**
CO4	**2**		**1**	**3**	**1**

Note : High - 1, Medium – 2, and Low – 3

DESIGN FOR MANUFACTURING AND ASSEMBLY			
Course Code	**22MDE/MEA/MMD244**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 hours + 10-12 activities	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

1. Understanding the basic rules for design for manufacturing and material selection.
2. Applying the guidelines for ease of design, manufacturing and assembly.
3. Analyze factors for selection of material and process, relationship to manufacturing processes
4. Apply the concepts of design for manufacturing and assembly for product manufacturing.
5. Compare various manufacturing processes and assembly techniques required for product development to optimise the process.

MODULE-1(5 Hours)

Material and process selection – Introduction, Advantages of applying DFMA, General requirements of early materials and process selection, Selection of Manufacturing processes, Selection of materials. Engineering Design features. – Dimensioning, Tolerances, General Tolerance, Geometric Tolerances,

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Assembly limits, Datum features.
Component design – Machining Considerations – Drills, Milling cutters, Drilling, Keyways, Dowels, Screws, Reduction in machining areas, Simplification by separation and amalgamation, work piece holding, surface grinding, Examples.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3 (5 Hours)

Component design – Casting Considerations – Pattern, Mould, parting line, cast holes, machined holes, identifying parting line, special sand cores, designing to obviate sand cores. Examples

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Design for Injectionmolding and Sheet metal working – Injection molding materials, Molding cycle, Systems, molds, machine size, cycle time, Cost estimation, Insert molding, Design guidelines, Introduction to sheet metalworking.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE 5(5 Hours)

Selective Assembly: Interchangeable part manufacture and selective assembly, deciding the number of groups Group tolerance of Mating parts equal, Model total and group tolerances of shaft equal. Control of axial play- Introducing secondary machining operations, laminated shims, examples.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

- Product Design for Manufacture and Assembly – Geoffrey Boothroyd - Peter Dewhurst - Winston Knight
- Designing for Manufacturing – Harry Peck - Pitman Publications – 1983
- Dimensioning and Tolerancing for Quantity Production – Merhyle F Spotts –Inc. Englewood Cliffs - New Jersey - Prentice Hall, 5thedition.

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the principles of manufacturability and design for manufacture	2
CO2	Design casting for economic production.	4
CO3	Understand the concept of easy assembly, based on rules of DFMA to reduce the time of assembly.	2
CO4	Redesign the parts for easy manufacturing based on rules of DFMA to reduce the time of manufacturing and enhance cost effectiveness.	4
CO5	Design guidelines and background for powder metallurgy parts and reviewing of formed parts.	5

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	2
3	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**			**1**
CO2	**1**	**2**			**1**
CO3	**3**	**2**			**1**
CO4	**3**	**2**			**1**
CO5	**3**	**2**			**1**

Note : High - 1, Medium – 2, and Low – 3

INDUSTRY 4.0			
Course Code	**22MPD/MAU/MDE/MEA/MMD/MTP/MPY/MIA/MAR/CAE/MPE/MPM/MCM245**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- To impart basic idea in Industry 4.0.
- To provide students with good depth of knowledge of designing Industrial 4.0 Systems for various application
- Learn the concepts of Robotics and Augmented Reality

MODULE-1(8 Hours)

Introduction to Industry 4.0: Introduction, core idea of Industry 4.0,origin concept of industry 4.0,Industry 4.0 production system, current state of industry 4.0, Technologies, How is India preparing for Industry 4.0

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

A Conceptual Framework for Industry 4.0: Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Technology Roadmap for Industry 4.0: Introduction, Proposed Framework for Technology Roadmap, Strategy Phase, Strategy Phase, New Product and Process Development Phase.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Advances in Robotics in the Era of Industry 4.0: Introduction, Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

Obstacles and Framework Conditions for Industry 4.0 : Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers, comprehensive broadband infra- structure,

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Alp Ustundag and Emre Cevikcan,"Industry 4.0: Managing the Digital Transformation".
2. Bartodziej, Christoph Jan,"The Concept Industry 4.0".
3. Klaus Schwab,"The Fourth Industrial Revolution".
4. Christian Schröder,"The Challenges of Industry 4.0 for Small and Medium-sized Enterprises".

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars
- Industrial Visit
- Case study

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Describe Industry 4.0 and scope for Indian Industry	2
CO2	Demonstrate conceptual framework and road map of Industry 4.0	3
CO3	Describe Robotic technology and Augmented reality for Industry 4.0	3
CO4	Demonstrate obstacle and framework conditions for Industry 4.0	4

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program..	3

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**1**		
CO2	**2**	**3**	**1**		
CO3	**2**	**3**	**1**		
CO4	**1**	**3**	**1**		

Note : High - 1, Medium – 2, and Low – 3

MINI PROJECT WITH SEMINAR			
Course Code	**22MDE25**	CIE Marks	100
Number of contact Hours/Week	**0-4-2**	SEE Marks	--
Credits	**03**	Exam Hours/Batch	--

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project with seminar: This may be hands-on practice**,** survey report, data collection and analysis, coding, mobile app development, field visit and report preparation, modelling of system, simulation, analysing and authenticating, case studies, etc.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Students can present the seminar based on the completed mini-project. Participation in the seminar by all postgraduate students of the program shall be mandatory.

The CIE marks awarded for Mini-Project work and Seminar, shall be based on the evaluation of Mini Project work and Report, Presentation skill and performance in Question-and-Answer session in the ratio 50:25:25. Mini-Project with Seminar shall be considered as a head of passing and shall be considered for vertical progression as well as for the award of degree. Those, who do not take-up/complete the Mini Project and Seminar shall be declared as fail in that course and have to complete the same during the subsequent semester.

There is **no SEE** for this course.

Course outcomes:

At the end of the course the student will be able to:

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

FINITE ELEMENT LABORATORY			
Course Code	**22MDEL26**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:2:0	SEE Marks	50
Total Hours of Pedagogy	15 + 10 -12 Laboratory Sessions	Total Marks	100
Credits	2	Exam Hours	3

Course objectives:

- To familiarize the students with a commercial / open source FEM Software
- To make students practice problems in Linear Elastic, Dynamic and Non-Linear Finite Element Analysis using any commercial software such as NASTRAN/ABAQUS etc.

Sl.NO.	EXPERIMENTS
	Linear Static Analysis:
1	Linear Static Analyses of a Simply-Supported Truss, Simply-Supported Stiffened Plate and a Solid Lug.
2	Rigid Element Analysis with RBAR: Create a tube model with a 'rigid' end and apply a torque load for linear static analysis (Rigid Element Analysis with RBAR or equivalent)
	Dynamic Analysis:
3	Modal Analysis of a Flat Plate: find first five natural frequencies and mode shapes). Repeat the analysis with static reduction.
4	Direct Transient Response Analysis:Using the direct method, define time-varying excitation and compute nodal displacement for desired time domain. Repeat the analysis using the modal method.
5	Direct Frequency Response Analysis:Using the direct method define frequency-varying excitation and compute nodal displacement for desired frequency domain. Repeat the analysis with modal method
6	Random Analysis of flat plat: Determining the displacement response spectrum from random pressure and force loads with cross spectrum correlation.
	Non-Linear Analysis:
7	Spring Element with Nonlinear Analysis Parameters (Multi-Step Analysis): Demonstrate the effects of geometric nonlinear analysis with incremental loads through multiple subcases and interpret the results with different output options.
8	Geometric Nonlinear Analysis of a Cantilever Beam: Perform nonlinear analysis on a cantilever beam under four increasing loads, create an accurate deformation plot of the model and a plot of the load factor vs. displacement.
	DEMONSTRATION EXPERIMENTS (FOR CIE)
9	A plate with a part-through crack: elastic line spring modelling:A large plate with a symmetric, centrally located, semi-elliptic, part-through crack is subjected to edge tension and bending. Estimate the Mode I stress intensity factor, KI as a function of position along the crack front.
10	Z-section cantilever under torsional loading. A Z section cantilever (1 m, 2m,1m) with thickness 0.1 m is subjected to a torque of 1.2 MN-m applied at $x = 10$. The torque is applied by two uniformly distributed edge shears of 0.6 MN at each flange when shell elements are used. All displacements are zero along the edge at $x = 0$. The material properties are Young's modulus = 210 GPa, Poisson's ratio = 0.3, density = 7800 kg/m3. In the explicit dynamic analysis the loading rate is applied such that a quasi-static solution is obtained. Find the axial stress, σ_{xx} at mid-surface, and stress at point A (2.5 m from fixed edge).

11	Plane stress elements—elliptic membrane (NAFEMS Benchmark Problem): A thin steel plate of thickness 0.1 mm defined between two ellipses (outer: $\frac{x}{3.25^2}+\frac{y}{2.75}=1$ and inner: $\frac{x}{2^2}+\frac{y}{1^2}=1$) is subjected to uniform outer pressure of 10 MPa. Find Tangential edge stresses (σyy).
12	Laminated strip under three-point bending: A Laminate of size(50 mm x10 mm x1 mm), Lamina arrangement of0/90/0/90/0/90/0 (all lamina with thickness 0.1mm and the middle lamina with thickness 0.4mm) have the material properties E_1 = 100 GPa, E_2 = 5 GPa, E_3 = 5 GPa, ν_{12} = 0.4, ν_{13} = 0.3, ν_{23} = 0.3, G_{12} = 3 GPa, G_{13} = 2 GPa, G_{23} = 2 GPa . The plate is simply supported by two supports at 10 mm from ends. A Line load of10 N/mm is applied at the centre (x = 25, z = 1). Find the stresses, σ_{11} and σ_{13} and Uz.

Course outcomes (Course Skill Set):

At the end of the course the student will be able to:

- Run a Linear Static, Dynamic and Non- Linear Analysis for simple components
- Find the stress and displacement in a commercial software
- Demonstrate the validity of FE results against a set standard.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled downed to 30 marks (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 02 tests for 100 marks, the first test shall be conducted after the 8th week of the semester and the second test shall be conducted after the 14th week of the semester.
- In each test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The average of 02 tests is scaled down to **20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and average marks of two tests is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute; examiners are appointed by the University.

- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
- Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

1. https://www.scc.kit.edu/scc/sw/msc/Webwork/NasBooks.html
2. Abaqus Examples problem guide: http://wufengyun.com:888/books/exa/default.htm?startat=pdx01pdd01.html
3. National Agency for Finite Element Methods and Standards (U.K.): Test LE1 from NAFEMS publication TNSB, Rev. 3, "The Standard NAFEMS Benchmarks," October 1990.
4. http://wufengyun.com:888/books/bmk/default.htm?startat=book01.html#bmk
5. National Agency for Finite Element Methods and Standards (U.K.): Test R0031/1 from NAFEMS publication R0031, "Composites Benchmarks," February 1995. (http://wufengyun.com:888/books/bmk/default.htm?startat=book01.html#bmk)
6. National Agency for Finite Element Methods and Standards (U.K.): Test LE5 from NAFEMS publication TNSB, Rev. 3, "The Standard NAFEMS Benchmarks," October 1990. (http://wufengyun.com:888/books/bmk/default.htm?startat=book01.html#bmk)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus
M. Tech., Design Engineering. (MDE)
(Effective from the Academic year 2022-23)

Registrar,
Visvesvaraya Technological University
Jnana Sangam, Machhe, Belagavi-590018
eMail: registrar@vtu.ac.in
contact: 0831-2498112

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M. Tech., Design Engineering (MDE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini-Project/ Internship	Tutorial/ Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	22MDE/MEA/MMD31	Mechanics of Composite Materials	03	00	02	03	50	50	100	4
2	PEC	22MDE32X	Professional elective 3	03	00	00	03	50	50	100	3
3	OEC	22MDE33X	**Professional Elective 4**	03	00	00	03	50	50	100	3
4	PROJ	22MDE34	Project Work phase -1	00	06	00	--	100	--	100	3
5	SP	22MDE35	Societal Project	00	06	00	--	100	--	100	3
6	INT	22MDEI36	Internship	(06 weeks Internship Completed during the intervening vacation of II and III semesters.)			03	50	50	100	6
TOTAL				**09**	**12**	**03**	**12**	**400**	**200**	**600**	**22**

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students)

Professional elective 3		**Professional Elective 4**	
Course Code under 22MDE/MEA/MMD31X	**Course title**	**Course Code under 22MDE32X**	**Course title**
22MDE/MPD/MEA/MMD/MST321	Sustainability Engineering	22MDE/MEA/MMD/MTR/MPM331	**Design automation with IoT**
22MDE/MEA/MMD/MPD/MAU/MPE/MSE/MTE/MPY/MPM322	Rapid Prototyping	22MDE/MEA/MMD332	Reverse Engineering
22MDE/MPD/MEA/MMD/MST/MPT/323	Design of Experiments	22MDE/MEA/MMD333	Optimization through MATLAB
22MDE324	Design of Aerospace Structures	22MDE/MAU/MEA/MMD334	Introduction to hybrid and Electric Vehicles
22MDE325	Introduction to Robotics	22MDE/MEA/MMD335	3D Printing

Note:

1. Project Work Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

2. Societal Project: Students in consultation with the internal guide as well as with external guide (much preferable) shall involve in applying technology to workout/proposing viable solutions for societal problems.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

Those, who have not pursued /completed the Societal Project, shall be declared as fail in the course and have to complete the same during subsequent semester/s after satisfying the Societal Project requirements. There is no SEE (University examination) for this course.

3. Internship: Those, who have not pursued /completed the internship, shall be declared as fail in the internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase-1 shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examinations – 2020 - 21
M. Tech., DesignEngg. (MDE)
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	22MDE41	Project work phase -2	--	08	03	100	100	200	18
			TOTAL	--	**08**	**03**	**100**	**100**	**200**	**18**

Note:

1. Project Work Phase-2:

Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question and Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Total Credits 22+18+22+18 =**80**

Program Outcomes (POs)

1. **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.

2. **PO2:** An ability to write and present a substantial technical report/document.

3. **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.
4. **PO4**: Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.
5. **PO5**: Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions

III SEMESTER

MECHANICS OF COMPOSITE MATERIALS			
Course Code	**22MDE/MEA/MMD31**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	40 + 10-12 Activities	Total Marks	100
Credits	04	Exam Hours	03

Course Learning objectives:

This course will enable students to

1. Comprehend the basics of Composite Materials
2. Select composite materials,
3. Conduct stress and Stiffness analyses of Lamina and Laminate
4. Use the theories of failure of composite materials under static loading

MODULE-1(7 Hours)

Introduction: Basic Concepts, Design Process, Composites Design Methods, Fracture Mechanics.

Materials: Fiber Reinforcements, Fiber Types-Glass Fibers, Silica and Quartz Fibers, Carbon Fibers, Carbon Nanotubes, Organic Fibers, Boron Fibers, Ceramic Fibers, Basalt Fibers, Metallic Fibers, Natural Fibers; Fiber-Matrix Compatibility, Fiber Forms, Matrix Materials, Thermoset Matrices, Thermoplastic Matrices, Biodegradable Matrices, Creep, Temperature, and Moisture, Corrosion Resistance, Flammability

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(9 Hours)

Micromechanics: Basic Concepts Volume and Mass fraction, Heterogeneous Material, Anisotropic Material, Orthotropic Material, Transversely Isotropic Material, Isotropic Material; Stiffness-Longitudinal Modulus, Transverse Modulus, In-Plane Poisson's Ratio, In-Plane Shear Modulus, Intralaminar Shear Modulus, Restrictions on the Elastic Constants,

Strength - Longitudinal Tensile Strength, Longitudinal Compressive Strength, Transverse Tensile Strength, Mode I Fracture Toughness, In-Plane Shear Strength, Mode II Fracture Toughness, Transverse Compressive Strength, Mohr-Coulomb Failure, Intralaminar Shear Strength.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Ply Mechanics: Coordinate Systems, Stress and Strain, Stress-Strain Equations, Off-Axis Stiffness, Specially Orthotropic Lamina.

Macromechanics: Plate Stiffness and Compliance, Computation of Stresses, Common Laminate Types, Laminate Moduli, Universal Carpet Plots.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(9 Hours)

Ply Strength: Lamina Failure Criteria-Strength Ratio, Maximum Stress Criterion, Maximum Strain Criterion, Interacting Failure Criterion, First Ply Failure, Last Ply Failure, Laminate Strength.	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(7Hours)

Manufacturing Processes: Hand Layup, Prepreg Layup, Bag Molding, Autoclave Processing, Compression Molding, Resin Transfer Molding, Vacuum-Assisted Resin Transfer Molding, Pultrusion, Filament Winding, Textile Manufacturing.	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**
CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Ever J. Barbero, "Introduction to Composite Materials Design", 3rd Edition, CRC Press, 2018
2. Autar K. Kaw," Mechanics of composite materials", CRC, 2nd Edition, Indian Print, 2009

Web links and Video Lectures (e-Resources):

1. Introduction to Composites, IIT Kanpur, https://nptel.ac.in/courses/112104168
2. Composite Materials and Structures, IIT Kanpur, https://nptel.ac.in/courses/101104010

Skill Development Activities Suggested

1. Write a MATLAB programme to find the stress and strain of an angle lamina
2. Write a MATLAB code to find A,B, D Matrix of a Laminate and to find strains when subjected to applied stresses.
3. Write a MATLAB code to accommodate the theories of failure for composite materials

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Select Composite Materials based on the need of the situation	3
CO2	Design and analyse the lamina in its various orientations	3
CO3	Design and Analyse a composite laminate	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5
4		
5		

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**		**1**		**2**
CO2	**1**		**1**		**2**
CO3	**1**		**1**		**2**

Note : High - 1, Medium – 2, and Low – 3

Professional Elective 3

SUSTAINABILITY ENGINEERING			
Course Code	**22MDE/MPD/MEA/MMD/MST321**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To have an increased awareness among students on issues in areas of sustainability
2. To understand the role of engineering and technology with sustainable development.
3. To know the methods, tools and incentives for sustainable products service system development
4. To establish clear understanding of the role and impact t of various aspects of engineering decisions on environmental, societal and economic problems

MODULE-1	
Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development.	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-2	
Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, legal provisions for environmental protection.	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-3	
Environmental Management Standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA),	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-4	
Resources and its Utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels,	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
MODULE-5	
Sustainability Practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanization, Sustainable cities, Sustainable transport	
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks**or**oneSkill Development Activity of 40 marks**to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

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Suggested Learning Resources:

Books

1. Allen, D .T. and Shonnard, D .R., Sustainability Engineering: Concepts, Design and case studies, Prentice Hall
2. Bradley, A.S; Adebayo, A.O; Maria, P, Engineering applications in sustainable design and development, Cengage learning.
3. Environmental Impact assessment guidelines, Notification of Govt of India, 2006.
4. Mackenthun, K M; Basic concepts in Environmental management, Lewis publication, London 1998
5. Ni bin Chang, Systems analysis for sustainable engg Theory and applications, Mcgraw Hill professional.

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Case study
- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the relevance and the concept of sustainability and the global initiatives in this direction	
CO2	Explain the different types of environmental pollution problems and their sustainable solutions	
CO3	Discuss the environmental regulations and standards	
CO4	Outline the concepts related to conventional and non-conventional energy	
CO5	Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles	

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**	**2**	**3**	**3**	**2**
CO2	**3**	**3**	**1**	**3**	**1**
CO3	**1**	**2**	**1**	**3**	**2**
CO4	**3**	**3**	**1**	**3**	**1**
CO5	**1**	**3**	**1**	**2**	**1**

Note : High - 1, Medium – 2, and Low – 3

RAPID PROTOTYPING			
Course Code	**22MDE/MEA/MMD/MPD/MAU/MPE/MSE/MTE/MPY/MPM322**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 theory + 10-12 activates	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Describe product development, conceptual design and classify rapid prototyping systems; explain stereo lithography process and applications
2. Applying of measurement and scaling technique for prototype manufacturing.
3. Identify The process photopolymers, photo polymerization, layering technology, laser and laser scanning

MODULE-1(5 Hours)

Introduction: Need for the compression in product development, history of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Stereo Lithography Systems: Principle, Process parameter, Process details, Data preparation, data files and machine details, Application, **Selective Laser Sintering and Fusion Deposition Modeling**: Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, Principle of Fusion deposition modeling, Process parameter, , Applications.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Solid Ground Curing: Principle of operation, Machine details, Applications. Laminated Object Manufacturing: Principle of operation, LOM materials. Process details, application.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Rapid Tooling: Indirect Rapid tooling -Silicone rubber tooling – Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3Q keltool,

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Direct Rapid Tooling Direct. AIM, Quick cast process, Copper polyamide, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling soft Tooling vs. hard tooling.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks**or**oneSkill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Paul F. Jacobs ,"Stereolithography and other RP&M technologies- from rapid prototyping to rapid tooling", - Dearborn, Mich. : Society of Manufacturing Engineers in cooperation with the Rapid Prototyping Association of SME ; New York : ASME Press .1996
2. Rapid Manufacturing - Flham D.T &Dinjoy S.S - Verlog London2001.
3. Rapid automated - Lament wood - Indus press NewYork (4)Wohler's Report 2000 - Terry Wohlers - Wohler's Association -2000

Web links and Video Lectures (e-Resources):

- Rapid Manufacturing https://archive.nptel.ac.in/courses/112/104/112104265/

- VTU e-Shikshana Program
- VTU EDUSAT Program

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars
- Case study

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Describe product development, conceptual design and classify rapid prototyping systems; explain stereo lithography process and applications.	2
CO2	Explain direct metal laser sintering, LOM and fusion deposition modelling processes.	2
CO3	Demonstrate solid ground curing principle and process.	4
CO4	Discuss LENS, BPM processes; point out the application of RP system in medical field define virtual prototyping and identify simulation components.	3
CO5	Understand the RP Process Optimizations.	2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**		**1**	**3**	
CO2	**3**		**1**	**2**	
CO3	**3**		**1**	**2**	
CO4	**2**		**1**	**3**	
CO5	**3**		**1**	**3**	

Note : High - 1, Medium – 2, and Low – 3

DESIGN OF EXPERIMENTS			
Course Code	**22MDE/MPD/MEA/MMD/ MST/MPT/323**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25+10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To develop an understanding of experimental methods and major experimental designs and think critically about their proper application.
2. Write hypotheses that can be tested using experiments.
3. Be able to develop different types of experimental designs

MODULE-1(5 Hours)

Introduction: Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Basic Statistical Concepts: Concepts of random variable, probability, density function cumulative distribution function. Sample and population, Measure of Central tendency; Mean median and mode, Measures of Variability, Concept of confidence level. Statistical Distributions: Normal, Log Normal Illustration through Numerical examples.

Hypothesis testing, Probability plots, choice of sample size. Illustration through Numerical examples.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Experimental Design: Factorial Experiments, factors, levels, interactions, treatment combination, randomization, Two-level experimental designs for two factors and three factors. Three-level experimental designs for two factors and three factors, Factor effects, Factor interactions,

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(5 Hours)

Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Montgomery, D. C. (2019). Design and Analysis of Experiments, 10th Edition, John Wiley & Sons.
2. John Lawson,"Design and Analysis of Experiments with R", 1st Edition, Taylor and Francis, 2014.

Web links and Video Lectures (e-Resources):

1. Design and Analysis of Experiments (https://onlinecourses.nptel.ac.in/noc21_mg48/preview)
2. Sotware, JMP: https://www.jmp.com/en_ch/applications/design-of-experiments.html
3. R: https://www.r-project.org/
4. R Studio :https://posit.co/

Skill Development Activities Suggested

1. Implement the DoE techniques using R Software:

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Describe the fundamentals of experiments and its uses	2
CO2	Apply of statistical models, ANOVA in analysing experimental data	3
CO3	Analyse the data and identify the significant factors which influence the results	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**1**	**3**	**1**
CO2	**3**	**3**	**1**	**3**	**1**
CO3	**3**	**3**	**1**	**3**	**1**

Note : High - 1, Medium – 2, and Low – 3

Professional Elective 4

DESIGN OF AEROSPACE STRUCTURES			
Course Code	**22MDE324**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To study basic concepts of aircraft structures & materials, and various types of loads acting on an aircraft.
2. To understand concepts of open and closed thin walled beams.
3. To acquire the knowledge of buckling of plates, joints and fittings.
4. Comprehend the stress analysis on wings and fuselage.

MODULE-1(8 Hours)

Loads on Aircraft and Aircraft Materials:

Loads on Aircraft and Aircraft Materials Loads on Aircraft: Structural nomenclature, Types of loads, load factor, Aerodynamics loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components.

Aircraft Materials: Metallic and non-metallic materials, Use of Aluminum alloy, titanium, stainless steel and composite materials. Desirable properties for aircraft application.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Bending of Open and Closed Thin Walled Beams:

Symmetrical bending, unsymmetrical bending, direct stress distribution due to bending, position of the neutral axis, load intensity, shear force, and bending moment relationships, deflection due to bending, calculation of section properties, approximation for thin-walled sections.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Shear and Torsion of Open and Closed Thin Walled Beams:

General stress, strain, and displacement relationship for open and single-cell closed section thin-walled beams, shear of open section beams, shear centre, shear of closed section beams. Torsion of close section beam, and displacement associated with the Bredt-Batho shear flow. Torsion of open section beam. Combined bending, shear, torsion.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Buckling of Plates, Joints and Fittings:

Buckling of Isotropic flat plates in compression, ultimate compressive strength of Isotropic flat sheet, plastic buckling of flat sheet, columns subjected to local crippling failure, Needham & Gerard method for determining crippling stress, curved sheets in compression, elastic buckling of curved rectangular plates. Pure tension field beams, angle of diagonal tension in web. Joints and Fittings- bolted or riveted joints, accuracy of fitting analysis, eccentrically loaded connections, welded joints, and concept of effective width.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

Stress Analysis in Wing Spars and Box beams: Tapered wing spar, open and closed section beams, beams having variable stringer areas, three- boom shell, torsion and shear, tapered wings, cut-outs in wings.

Stress Analysis in Fuselage Frames: Bending, shear, torsion, cut-outs in fuselages, principles of stiffeners construction, fuselage frames, shear flow distribution.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Megson, T. H. G., "Aircraft Structures for Engineering Students", Edward Arnold, 1995, ISBN-10:
2. Peery D J & Azar J J, "Aircraft Structures", McGraw Hill N.Y, 2nd edition,1993,
3. Bruhn E. F, "Analysis & Design of Flight Vehicles Structures", Tri-State offset Co, USA, 1985, ISBN-10:

Web links and Video Lectures (e-Resources):

1. Aircraft Structures - I, IIT Kharagpur (https://archive.nptel.ac.in/courses/101/105/101105084/)

Skill Development Activities Suggested

1. Industrial visit at any aerospace organization.

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the various loads acting on aircraft.	2
CO2	Understand various types of materials used in aircraft configuration.	2
CO3	Apply the concept of thin walled beams.	3
CO4	Calculate the buckling of plates.	3
CO5	Analyze the stresses in wings and fuselage structures / frames.	4

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
3	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**			**2**	**1**
CO2	**3**			**2**	**1**
CO3	**2**			**2**	**1**
CO4	**2**			**2**	**1**
CO5	**1**			**3**	**3**

Note : High - 1, Medium – 2, and Low – 3

INTRODUCTION TO ROBOTICS			
Course Code	**22MDE325**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Develop the knowledge in various robot structures and their workspace.
- Develop the skills in performing kinematics analysis of robot systems.
- Provide the knowledge of the dynamics associated with the operation of robotic systems.
- Provide the knowledge and analysis skills associated with trajectory planning.
- Understand material handling and robot applications in industries.

MODULE-1(8 Hours)

Introduction: Automation and robotic, an over view of robotics, classification by coordinate system and control systems; Components of the industrial robotics: Degrees of freedom, end effectors: Mechanical gripper, magnetic, vacuum cup and other types of grippers, general consideration on gripper selection and design.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Motion analysis: Basic rotation matrices, composite rotation matrices, Euler angles, equivalent angle and axis, homogeneous transformation, problems; Manipulator kinematics: D-H notations, joint coordinates and world 2 | P a g e coordinates, forward and inverse kinematics, problems.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Differential kinematics: Differential kinematics of planar and spherical manipulators, Jacobians problems. Robot dynamics: Lagrange, Euler formulations, Newton-Euler formulations, problems on planar two link manipulators.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Trajectory planning: Joint space scheme, cubic polynomial fit, avoidance of obstacles, types of motion: Slew motion, joint interpolated motion, straight line motion, problems, Robot actuators and feedback components; Actuators: pneumatic and hydraulic actuators.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

Electric actuators: DC servo motors, stepper motors, feedback components: position sensors, potentiometers, resolvers and encoders, velocity sensors, tactile sensor; Robot application in manufacturing: Material handling, assembly and inspection.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Three Unit Tests each of **20 Marks**
2. Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Groover M. P, "Industrial Robotics", Tata McGraw-Hill, 1st Edition, 2013.
2. J. J. Criag, "Introduction to Robotic Mechanics and Control", Pearson, 3rd Edition, 2013.
3. Richard D. Klafter, "Robotic Engineering", Prentice Hall, 1st Edition, 2013.
4. Fu K S, "Robotics", McGraw-Hill, 1st Edition, 2013.

Web links and Video Lectures (e-Resources):

- https://www.doc.ic.ac.uk/~ajd/Robotics/RoboticsResources/lecture1.pdf
- http://opencourses.emu.edu.tr/course/view.php?id=32
- https://www.researchgate.net/publication/277712686_Introduction_to_Robotics_class_notes_UG_level
- http://www.robot.bmstu.ru/
- http://www.robotee.com/index.php/download-free-robotic-e-books/

Skill Development Activities Suggested

- Quizzes
- Assignments
- Seminars
- Industrial Visit
- Case study

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand characteristic features of robots and usage of different grippers for industrial applications.	2
CO2	Understand direct and inverse kinematics of robot structure	2
CO3	Apply the concepts of Differential Kinematics of planar and spherical manipulators.	3
CO4	Understand classification of robot actuators and trajectory planning.	2
CO5	Analyse material handling and applications in manufacturing.	4

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
3	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**2**		**1**	**2**	
CO2	**3**		**1**	**3**	
CO3	**3**		**1**	**3**	
CO4	**2**		**1**	**2**	
CO5	**3**		**1**	**3**	

Note : High - 1, Medium – 2, and Low – 3

DESIGN AUTOMATION WITH IoT			
Course Code	**22MDE/MEA/MMD /MTR/MPM331**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:0:2	SEE Marks	50
Total Hours of Pedagogy	25 + 10-12 Activities	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

1. To introduce students to the field of IoT
2. To familiarise students' different types of sensors used in automation
3. To provide awareness about the applications of IoT

MODULE-1(5 Hours)

Introduction to IoT & Cyber-Physical Systems, IoT Enabling Technologies– Physical End points, Network Services, Cloud. Different Levels of IoT Applications.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Communication and networking technologies in IoT: Communication models, AdHoc. Industrial & Automotive Networks, Vehicular networks

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3 (5 Hours)

Thermo resistive Sensors- Thermistors, Resistance Temperature Sensors, and Silicon Resistive Sensors, Thermo electric sensors, PN junction temperature sensors, thermos mechanical sensors and actuators. Photoelectric sensors, optical actuators.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(5 Hours)

Mechanical Sensors and Actuators- force sensors, pressure sensors, Acoustic actuators, ultrasonic sensors and actuators. MEMS and Smart sensors- pressure sensors, thermal and piezo electric actuation, wireless sensors and actuators.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE 5(5 Hours)

IoT implementation in Transportation and logistics, Energy and utilities, Automotive Connected supply chain, Plant floor control automation, remote monitoring.

Applications HCI and IoT world -Multilingual interactions Robotics and Autonomous Vehicles Sensing and data processing-Simultaneous mapping and localization-Levels of autonomy, Smart factories, Future research Challenges.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is

% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **20 Marks**
2. Two assignments each of **10 Marks/One Skill Development Activity of 20 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The**15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to 15 marks.
- The laboratory test at the end /after completion of all the experiments shall be conducted for 50 marks and scaled down to 05 marks**.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

- The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
- The question paper will have ten questions. Each question is set for 20 marks.
- There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
- The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.

- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course(CIE+SEE)

Suggested Learning Resources:

Books

1. Adrian McEwan and Hakim Cassimally, "Designing the internet of things", Wiley, 2013

2. Vijay Madisetti and Arshdeep Bahga,"Internet of Things (A Hands-on-Approach)",1st Edition,VPT, 2014.

3. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

4. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies & Sensors for the Internet of Things Businesses & Market Trends 2014 - 2024',YoleDéveloppement Copyrights ,2014

5. Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.

6. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David

7. Boyle, "From Machine-to-Machine to the Internet of Things -Introduction to a New Ageo Intelligence" Elsevier

Web links and Video Lectures (e-Resources):

- VTU e-Shikshana Program
- VTU EDUSAT Program

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Quizzes
- Assignments
- Seminars

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the principles of manufacturability and design for manufacture	2
CO2	Design casting for economic production.	4
CO3	Understand the concept of easy assembly, based on rules of DFMA to reduce the time of assembly.	2
CO4	Redesign the parts for easy manufacturing based on rules of DFMA to reduce the time of manufacturing and enhance cost effectiveness.	4
CO5	Design guidelines and background for powder metallurgy parts and reviewing of formed parts.	5

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	2
3	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	3	2			1
CO2	1	2			1
CO3	3	2			1
CO4	3	2			1
CO5	3	2			1

Note : High - 1, Medium – 2, and Low – 3

REVERSE ENGINEERING			
Course Code	**22MDE/MEA/MMD332**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

This course will enable students to

1. Understand basic engineering systems.
2. Understand the terminologies related to re-engineering, forward engineering, and reverse engineering.
3. Understand Reverse Engineering methodologies.
4. Understand Reverse engineering of Systems, Mechanical RE, Electronic RE, and Computer RE

MODULE-1(8 Hours)

Introduction to Reverse Engineering: Introduction, What Is Reverse Engineering?, Why Use Reverse Engineering?, Reverse Engineering–The Generic Process, Phase 1–Scanning, Phase 2–Point Processing, Phase 3–Application Geometric Model Development.

Methodologies and Techniques for Reverse Engineering: Computer-aided Reverse Engineering, Computer Vision and Reverse Engineering, Structured-light Range Imaging, Scanner Pipeline.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Reverse Engineering–Hardware and Software: Introduction, Reverse Engineering Hardware, Reverse Engineering Software.

Selecting a Reverse Engineering System: The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, Issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, Destructive Systems, Some Comments on Accuracy, Positioning the Probe, Post-processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing Approaches.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Introduction to Rapid Prototyping: The Basic Process, Current Techniques and Materials, Applications, Future.

Relationship Between Reverse Engineering and Rapid Prototyping: Introduction, The Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Determination of Adaptive Layer Thickness, Some Application Examples.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Reverse Engineering in the Automotive Industry: Introduction, Reverse Engineering– Workflow for Automotive Body Design, Reverse Engineering for Better Quality, A Look Ahead–Convergence of Digital and Physical Worlds.

Reverse Engineering in the Aerospace Industry: Introduction,RE in Aerospace–A Work in Progress,Reducing Costs of Hard Tooling,Inspection in Half the Time,Making the Next Great Leap.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

Reverse Engineering in the Medical Device Industry: Introduction,Orthodontics Without Wires and Brackets,Improving the Scanning Process,The Six-stage Process,Achievement,Digital Dentistry Becomes Reality,Hearing Instruments Meet the Digital Age,Reverse Engineering–A Better Knee Replacement,The Quest for a Total Artificial Heart,Moving Toward Mass Customization.

Barriers to Adopting Reverse Engineering: Background,The Research Model,Research Methodology,Factor Analysis Approach,Findings.

Legal Aspects of Reverse Engineering:Introduction,Copyright Law,Reverse Engineering,Recent Case Law.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Vinesh Raja and Kiran J. Fernandes (Eds.)," Reverse Engineering : an industrial perspective.", Springer series in advanced Manufacturing, Springer-Verlag London Limited 2008.
2. Wego Wang,Reverse Engineering Technology of Reinvention,CRC Press, 2011.

Web links and Video Lectures (e-Resources):

1. Rapid Manufacturing (**http://www.nitttrc.edu.in/nptel/courses/video/112104265/L12.html**)
2. UltimakerCura Software: **https://ultimaker.com/software/ultimaker-cura**
3. PreForm Software: **https://formlabs.com/asia/software/**
4. Invesalius Software: **https://invesalius.github.io/download.html**

Skill Development Activities Suggested

1. Explore the software mentioned above and try to some slicing operations of the available CAD models

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Understand the Reverse Engineering (RE) Methodology	4
CO2	Disassemble products and specify the interactions between its subsystems and their functionality	2
CO3	Understand Computer-Aided RE and Rapid Prototyping Technology	3
CO4	Experiments with open-source software used in RE	2

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**	**3**	**1**	**3**	
CO2	**3**	**3**	**1**	**2**	
CO3	**1**	**3**	**1**	**2**	
CO4	**1**	**2**	**1**	**1**	

Note : High - 1, Medium – 2, and Low – 3

OPTIMIZATION THROUGH MATLAB			
Course Code	**22MDE/MEA/MMD333**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	2:2:0	SEE Marks	50
Total Hours of Pedagogy	25+ 10 Labs	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. To understand basic engineering optimization techniques and their applications.
2. To introduce the mathematical preliminaries required for optimization.
3. To understand basic linear and nonlinear programming techniques.
4. To understand multi-objective optimization techniques.
5. To understand linear and nonlinear integer programming techniques.
6. To understand various MATLAB programs for solving linear & nonlinear programming problems, multi-objective optimization problems, and integer programming problems.

MODULE-1(5 Hours)

Introduction: Introduction, historical development, engineering applications of optimization, statement of an optimization problem, classification of optimization problems, optimization techniques. Solution of optimization problem using MATLAB.

Mathematical Preliminaries: Overview, vectors and geometry – dot product, equation of a line, equation of a plane; basic linear algebra: preliminary definitions, matrix operations, determinants, inverse, eigenvalues, eigenvectors, positive definiteness; basic calculus: types of functions, derivative, integration and taylor series; optimization basics.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(5 Hours)

Linear Programming: Overview, basics of linear programming (LP), single objective optimization, solution approaches: analytical, numerical, experimental and graphical.

Simplex Methods: Standard form, Gauss Jordan elimination, reducing to row echelon form, the basic solution; duality; simplex algorithm. Solving LP problems using MATLAB.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(5 Hours)

Nonlinear Programming with No Constraints: Overview, necessary and sufficient conditions, single variable optimization, multivariable optimization. MATLAB solutions.

Nonlinear Programming with Constraints: Overview, structure of constrained optimization, elimination method, penalty methods, Karush-Kuhn-Tucker conditions, sequential linear programming, sequential quadratic programming. MATLAB solutions.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

	MODULE-4(5 Hours)
	Multiobjective Optimization: Overview, the multiobjective problem definition, pareto optimal solution, the weighted sum method, compromise programming, generating the pareto frontier with MATLAB, reaching a target - goal programming, expressing a preference – physical programming. Multiobjective optimization using MATLAB optimization toolbox. **Physical Programming for Multiobjective Optimization:** Overview, linear physical programming (LPP), nonlinear physical programming (NPP), comparison of LPP with goal programming.
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
	MODULE-5(5 Hours)
	Integer Programming: Introduction, integer linear programming – graphical representation, Gomory's cutting plane method; integer nonlinear programming – integer polynomial programming, branch-and-bound method, sequential linear discrete programming, generalized penalty function method. Solution of binary programming problem using MATLAB.
Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. S.S. Rao, "Engineering Optimization – Theory and Practice", 4th edition, John Wiley & Sons, Inc., 2009, ISBN 978-0-470-18352-6.
2. Achille Messac, "Optimization in Practice with MATLAB", Cambridge University Press, 2015, ISBN 978-1-107-10918-6.

Web links and Video Lectures (e-Resources):

1. Optimization, IIT Kharagpur (https://nptel.ac.in/courses/111105039)

Skill Development Activities Suggested

1. Development of MATLAB application for solving basic optimization problems.

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Define optimization terminology &concepts, and classify an optimization problem.	2
CO2	Understand basic mathematical concepts needed for solving optimization problems.	3
CO3	Apply mathematical concepts and optimization techniques to solve linear & nonlinear programming problems, multiobjective optimization problems, and integer programming problems.	3
CO4	Solve linear & nonlinear programming problems, multiobjective optimization problems, and integer programming problems using MATLAB.	3

Program Outcome of this course

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4
5	Students should be able to conduct analytical and experimental investigations on Industrial and societal problems to provide sustainable solutions.	5

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**	**3**	**1**	**2**	**2**
CO2	**2**	**3**	**1**	**3**	**3**
CO3	**1**	**3**	**1**	**2**	**2**
CO4	**1**	**3**	**1**	**2**	**2**

Note : High - 1, Medium – 2, and Low – 3

INTRODUCTION TO HYBRID AND ELECTRIC VEHICLES			
Course Code	**22MDE/MAU/MEA/MMD334**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

1. Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Analyze various electric drives suitable for hybrid electric vehicles.
3. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
4. Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

MODULE-1(8 Hours)

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

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.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Electric Propulsion unit: Introduction to electric 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.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

	Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
	MODULE-4(8 Hours)	
	Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems **Energy Management Strategies:** Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.	
	Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,
	MODULE-5(8 Hours)	
	Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	
	Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Web links and Video Lectures (e-Resources):

1. Introduction to Hybrid and Electric Vehicles - Web course https://archive.nptel.ac.in/courses/108/103/108103009/
2. Introduction to Hybrid Electric Vehicle Systems PD291809 (https://www.sae.org/learn/content/pd291809/)
3. Electric Vehicle Engineering Course (https://neat.aicte-india.org/course-details/NEAT2020627_PROD_1)
4. Electric Vehicles (https://www.aicte-india.org/sites/default/files/Model_Curriculum/fINAL%20-%20NEP%202020%20Model%20Syllabus%20for%20Open%20Electives%20in%20Electric%20Vehicles.pdf)

Skill Development Activities Suggested

1. Simulate the electric vehicle in MATLAB/SCILAB modules

Course outcome (Course Skill Set)

At the end of the course the student will be able to:

Sl. No.	Description	Blooms Level
CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies andfundamentals.	1
CO2	Explain the use of different energy storage devices used for hybrid electric vehicles, theirtechnologies and control and select appropriate technology	2
CO3	Interpret working of different configurations of electric vehicles and its components, hybridvehicle configuration, performance analysis and Energy Management strategies in HEVs.	4

Program Outcome of this course

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**1**		**1**		
CO2	**1**		**1**		
CO3	**1**		**1**		

Note : High - 1, Medium – 2, and Low – 3

3D PRINTING			
Course Code	**22MDE/MEA/MMD335**	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:
This course will enable students to
1. Understand basic Additive Manufacturing and 3D Printing
2. Understand the terminologies related to 3D Printing and allied technologies
3. Understand the materials and methods used in 3D printing

MODULE-1(8 Hours)

Introduction: The World of 3DP, Growth of RP and 3DP Systems, Current Popular 3D Printers, Applications in Education and Industry.

How Does 3D Printing Work?: 3D Printing and Conventional Manufacturing, Basics of 3D Printing Process, Problems with the STL File Format, Other Translators, Future Manufacturing Format Developments, Case Study: Design and Printing of Eye Bracket.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-2(8 Hours)

Design of a 3D Printer: Necessary Parts, Functional Description and Design Analysis, Build Process, Future Improvements.

Calibrating the 3D Printer: Introduction, Types of 3D Printing Software, 3D Printer Software Configuration Using Marlin, The First Print.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-3(8 Hours)

Materials for 3D Printing: Types of Materials, Liquid-Based Materials, Solid-Based Materials, Powder-Based Materials, Common Materials Used in 3D Printers, Materials Selection Considerations

Classifications of Rapid Prototyping and 3D Printing Systems: FDM Systems, SLA Systems, SLS Systems, Thermal Inkjet Printing Systems, Comparisons between Printing Processes.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-4(8 Hours)

Scanning and Reverse Engineering: Measuring Devices, CAD Model Construction from Point Clouds, Data Handling and Reduction Methods, Applications of RE, Case Studies- Recreation of Mechanical Parts and RE Prosthetics.

Common Applications of 3D Printers: Modeling Software, Design and 3D Printing of an Everyday Bottle Opener, Design and 3D Printing of a Flower Vase, Recreation of Human Face Using Reverse Engineering, Recreation of Human Fingers for Accident Victims.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

MODULE-5(8 Hours)

3D Printing in Medicine: Medical Applications of 3DP, Types of Medical Imaging, Software for Making Medical Models, Materials for Medical Applications, Methodology for Printing Medical Models, Benefits of 3DP in Medicine, 3D Printing of a C1 Vertebrate from CT Scan Data,

How to Select Rapid Prototyping and 3D Printer: Choosing 3D Printer, Operating Issues, Accessing 3DP and RP Systems, Development of an Expert System, Present and Future Trends.

Teaching-Learning Process	Power-point Presentation, Chalk and Talk are used for Problem Solving,

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- Three Unit Tests each of **20 Marks**
- Two assignments each of **20 Marks** or **one Skill Development Activity of 40 marks** to attain the COs and POs

The sum of three tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

- The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have a sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Rafiq Noorani,"3D Printing: Technology, Applications, and Selection", CRC Press, 2018
2. Ben Redwood, FilemonSchöffer& Brian Garret, "The 3D Printing Handbook - Technologies, Design, and Applications", 3D Hubs, 2017
3. Joan Horvath, "Mastering 3D Printing- Modeling, Printing, and Prototyping with REPRAP-STYLE 3D printers", Apress.
4. Ian Gibson, David Rosen, and Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, NY, 2015.
5. Kumar, L. Jyothish, Pulak M. Pandey, and David Ian Wimpenny, eds. 3D printing and additive manufacturing technologies. Singapore: Springer, 2019.

Web links and Video Lectures (e-Resources):

1. Rapid Manufacturing (http://www.nitttrc.edu.in/nptel/courses/video/112104265/L12.html)
2. Rapid Manufacturing (https://onlinecourses.nptel.ac.in/noc20_me50/preview)
3. Fundamentals of Additive Manufacturing Technologies (https://onlinecourses.nptel.ac.in/noc21_me115/preview)
4. UltimakerCura Software: https://ultimaker.com/software/ultimaker-cura
5. PreForm Software: https://formlabs.com/asia/software/
6. Invesalius Software: https://invesalius.github.io/download.html

Skill Development Activities Suggested

1. Explore the software mentioned above and try to some slicing operations of the available CAD models
2. Generate a small 3D Model using a 3D Printer

Course outcome (Course Skill Set)

At the end of the course the student will be able to :

Sl. No.	Description	Blooms Level
CO1	Explain the 3D Printing fundamentals, methods and methodologies.	4
CO2	Take a sample 3D CAD Model and convert it to an input required for 3D printing machine.	2
CO3	Select appropriate 3D printer and Rapid Prototyping Technology.	3

Program Outcome of this course

Sl. No.	Description	POs
1	An ability to independently carry out research/investigation and development work to solve practical problems.	1
2	An ability to write and present a substantial technical report/document.	2
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program.	3
4	Students should be able to design, synthesize and analyse a physical engineering systems using modern tools and techniques.	4

Mapping of COs and POs

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**3**	**1**	**2**	
CO2	**1**	**3**	**1**	**1**	
CO3	**1**	**3**	**1**	**2**	

Note : High - 1, Medium – 2, and Low – 3

PROJECT WORK PHASE – 1			
Course Code	**22MDE34**	CIE Marks	100
Number of contact Hours/Week	**0-6-0**	SEE Marks	**--**
Credits	**03**	Exam Hours	**--**

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1: The project work shall be carried out individually. However, in case a disciplinary or interdisciplinary project requires more participants, then a group consisting of not more than three shall be permitted.
Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall pursue a literature survey and complete the preliminary requirements of the selected Project work. Each student shall prepare a relevant introductory project document, and present a seminar.

Course Outcomes:

At the end of the course the student will be able to:

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation, and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

Continuous Internal Evaluation

- CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of **50:25:25**.
- There will be **no SEE**.

INTERNSHIP			
Course Code	**22MDEI36**	CIE Marks	50
Number of contact Hours/Week	**6 Weeks**	SEE Marks	50
Credits	**06**	Exam Hours	03

Course Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.

The objectives are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.

Internship: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

At the end of the course the student will be able to:

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics.

Continuous Internal Evaluation

CIE marks for the Internship report, presentation and question and answer session shall be awarded in the ratio of 50:25:25 for the **total CIE of 50 marks** by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments.

Semester End Examination

SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded in the ratio of 50:25:25 for the **total SEE of 50 marks** (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

IV SEMESTER

PROJECT WORK PHASE -2

Course Code	**22MDE41**	CIE Marks	100
Number of contact Hours/Week	**8 Hours/Week**	SEE Marks	100
Credits	**18**	Exam Hours	03

Course Objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instill responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Students in consultation with the guide/co-guide (if any) in disciplinary project or guides/co-guides (if any) of all departments in case of multidisciplinary projects, shall continue to work of Project Work phase -1to complete the Project work. Each student / batch of students shall prepare project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, all Guide/s and co-guide/s (if any) and a senior faculty of the concerned departments. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report, Project Presentation skill, and performance in the Question-and-Answer session in the ratio of 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

Course Outcomes:

At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.