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||Jai Sri Gurudev||

Sri Adichunchanagiri Shikshana Trust (R.)

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

AICTE Approved, Accredited by NAAC with A+ Grade & NBA (CSE, ISE, ECE, ME & CV), NIRF(151-300) in 2023,Gold Rated by QS I-Gauge

P.B. No.20, B.B Road, Chikkaballapur - 562 101, Karnataka

Estd : 1986

I & II Semester
Scheme & Syllabus of M.Tech Programme
Machine Design
(2024 Scheme)

Core Values

Spiritual, **J**udicious, **C**ommitment, **I**ntegrity, **T**rustworthy



NATIONAL INSTITUTIONAL RANKING FRAMEWORK 151-300

A+ NAAC

QS I-GAUGE GOLD

INSTITUTION'S INNOVATION COUNCIL (Ministry of HRD Initiative) 4-Star Rating

Department of Mechanical Engineering

Program: M.Tech. Machine Design

Vision

Building Technically Competent Design Engineers in Mechanical Domain to Serve the Society

Mission

M1: Imparting strong fundamental knowledge in Mechanical Engineering and allied fields.

M2: Fostering a culture of collaboration and propagating Industry Institute interactions to enhance advances in latest technologies.

M3: Creating State -of -Art facilities benefitting students and faculty to carryout Research, Innovation, and Consultancy.

M4: Providing conducive environment for both students and faculty to engage in lifelong learning activities.

M5: Inculcating Professional ethics, Leadership qualities and Entrepreneurial skills among students.

Program Educational Objectives

PEO-1: Design, analyze and simulate the concepts and tools for design and development of machine components and systems.

PEO-2: Develop life skills to become design professionals, administrators and Academicians.

PEO-3: Engage in lifelong learning to adopt socio-economic -technological developments.

Program Outcomes

PO1: Carryout independent research/investigation and development work to solve practical problems

PO2: Write and present a substantial technical report/document

PO3: Demonstrate a degree of mastery in machine design at a level higher than the bachelors programme

PO4: Use state of art tools and techniques to model and analyze machine components

PO5: Design, develop and evaluate mechanical components and systems

PO6: Engage in lifelong learning adhering to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

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Scheme of Teaching and Examinations

M.Tech., in Machine Design

Department Name: Mechanical Engineering

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

I SEMESTER (Core Courses related to main Engineering Stream)

Sl. No	Course Type	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/SDA	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	PCC	MME101	Waste to Energy	3	0	0	03	50	50	100	3
2	IPCC	MME102	Computer Simulation of Machines	3	2	0	03	50	50	100	4
3	IPCC	MME103	Mechatronics for Industrial Application	3	0	0	03	50	50	100	3
4	PEC	MME104x	Professional Elective I	3	0	0	03	50	50	100	3
5	PEC	MME105x	Professional Elective I	3	0	0	03	50	50	100	3
6	PCCL	MMEL106	Engineering Computational Tools Laboratory	0	4	0	03	50	50	100	2
7	NCMC	MRMC107	Research Methodology and IPR (Online)	Classes and Evaluation Procedures are as per the policy of the online course providers (online.vtu.ac.in OR nptel.ac.in)							PP
		OR									
		MMEC108	BoS Recommended online course								
Total				**15**	**6**	**0**	**18**	**350**	**350**	**700**	**18**

Professional Elective I		Professional Elective II	
MME104A	Theory of Metal Cutting and forming	MME105A	Additive Manufacturing Techniques
MME104B	Material Selection in Machine Design	MME105B	Smart Mobility
MME104C	Advance Fluid Mechanics	MME105C	Introduction to AI and ML
MME104D	Design of Experiments	MME105D	Industrial Robots

Note: **BSC**-Basic Science Courses, **PCC**: Professional core. **IPCC**-Integrated Professional Core Courses, **PCC(PB):** Professional Core Courses (Project Based), **PCCL**-Professional Core Course lab **,NCMC**- None Credit Mandatory Course, ,**L-**Lecture**, P-**Practical**, T/SDA-**Tutorial **/** Skill Development Activities(Hours are for Interaction between faculty and students) **MRMC108**- Research Methodology and IPR (**Online**) for the students who have **not studied** this course in the Undergraduate level. This course is not counted for vertical progression, Students have to qualify for the award of the master's degree. **MXXC108** - BoS Recommended online course for the students who have studied Research Methodology and IPR in Undergraduate level.

M- Master program **xx – MD** for Machine Design, SE for Structural Engineering, **DN** for Digital Communication and Networking, **CS** for Computer Science and Engineering **BA**- Business Administration.

BSC: Basic Science Courses: Courses like Mathematics/ Science are the prerequisite courses that the concerned engineering stream board of Studies will decide. **PCC: Professional Core Course:** Courses related to the stream of engineering, which will have both CIE and SEE components, students have to qualify in the course for the award of the degree. **Integrated Professional Core Course (IPCC)**: Refers to a Professional Theory Core Course Integrated with practical's of the same course. The IPCC's theory part shall be evaluated 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. **Project Based Learning Course (PCC(PB):** Project Based Learning course is a professional core Course only Students have to complete a project out of learning from the course and SEE will be viva voce on project work. **PCCL: Professional Core Course Laboratory:** Practical courses whose CIE will be evaluated by the class teacher and SEE will be evaluated by the two examiners.

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 the modelling of systems and algorithms for transient and steady-state operations, thermal study, etc.
7. Work on different software/s (tools) to simulate, analyze 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 are to be involved 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 that will enhance their skills. The prepared report shall be evaluated for CIE marks.

MRMC108-Research Methodology and IPR- None Credit Mandatory Course (NCMC) if students have not studied this course in their undergraduate program then he /she has to take this course at **http://online.vtu.ac.in or http://nptel.ac.in** and to qualify for this course is compulsory before completion of the minimum duration of the program (Two years), however, this course will not be considered for vertical progression.

Semester: I						
Waste to Energy						
Course Code	**:**	**MME101**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Differentiate and characterize different waste
CLO2	Recognize the various waste to energy conversion processes
CLO3	Explain various biochemical conversion processes.
CLO4	Explain various thermo-chemical conversion processes.
CLO5	Explain various biomass process to energy conversion.

Module – 1	**08 Hrs**
Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.	
Module – 2	**08 Hrs**
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.	
Module – 3	**08 Hrs**
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.	
Module – 4	**08 Hrs**
Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.	
Module – 5	**08 Hrs**
Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status – Bio energy system - Design and constructional features - Biomass resources and their classification – Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications – Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Differentiate and characterize different waste.
CO2	Recognize the various waste to energy conversion processes.
CO3	Explain various biochemical conversion processes.
CO4	Explain various thermo chemical conversion processes.
CO5	Explain various biomass process to energy conversion.

Text Books	
1	Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2	Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3	Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4	Biomass Conversion and Technology, C. Y. WereKo- Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Web links and Video Lectures (e-Resources)	
1	VTUe- Shikshana Program
2	VTU EDUSAT Program
Skill Development Activities Suggested	
1	Seminars
2	Assignments
3	Quizzes
4	Industrial Visit

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**2**	**3**			**2**
CO2	**1**	**2**	**2**			**2**
CO3	**1**	**2**	**2**			**2**
CO4	**1**	**2**	**3**			**2**
CO5	**1**	**2**	**2**			**2**

Semester: I						
Computer Simulation of Machines						
Course Code	:	MME102		**Credits**	:	04
Hours/Week(L:T:P)	:	3:0:2		**CIE**	:	50 Marks
Total Hours	:	50		**SEE**	:	50 Marks
Course Type	:	IPCC		**SEE Duration**	:	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Know the concepts used for kinematic analysis of planar and spatial mechanisms
CLO2	Familiarize with the concepts of synthesis of mechanisms.

Module – 1	**10 Hrs**
Introduction 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 Common Mechanisms, Vector Chains.	
Module – 2	**10 Hrs**
Introduction to synthesis (analytical methods) Freudenstein's equation - Precision point, approximation - Precision derivative approximation - Method of components - Block synthesis and Reven's method.	
Module – 3	**10 Hrs**
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.	
Module – 4	**10 Hrs**
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.	
Module – 5	**10 Hrs**
Two-link planar Robot Overview, Vector Equations, Dynamic Equations, The Simultaneous Constraint matrix, Dynamic Simulation, Robot Coordinate Control.	

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 Pendulum, Projectile Motion, Spring Damper
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

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply path curvature characteristics in analysis of mechanisms
CO2	Apply analytical and synthesis techniques in design of mechanisms.
CO3	Apply forward and reverse kinematic analysis techniques in performance evaluation of manipulators
C04	Analyze the design mechanisms and determine the parameters

Text 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.

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Write a MATLAB Program for kinematic analysis of Four bar mechanism
2	Write a program in MATLAB to simulate the forward kinematics of a 2R Robotic Arm.

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 Machines https://www.youtube.com/watch?v=MJeRFzs4oRU&list=RDCMUC640y4UvDAlya_WOj5U4pfA&index=2

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**		**1**	**2**	**1**	
CO2	**3**	**2**	**1**	**1**	**2**	
CO3	**3**		**1**	**3**	**2**	**1**
C04	**2**	**3**	**1**	**1**	**2**	**1**

Semester: I						
Mechatronics for Industrial Application						
Course Code	**:**	**MME103**		**Credits**	**:**	03
Hours/Week (L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the design process and integrated design issues in Mechatronics system
CLO2	Understand system models and its components
CLO3	Acquire the knowledge of Mechatronics in mobility
CLO4	Apply the concept of Mechatronics in manufacturing
CLO5	Apply the concept of Mechatronics in construction and bio mimics robot

Module – 1	**08 Hrs**
Introduction to Mechatronics: Mechatronics system architecture: Sensors, signal conditioners, PLC/embedded controllers, pneumatic, hydraulic and electric actuators. **Introduction to Real Time Mechatronics system:** Flexible Manufacturing systems, Computer Integrated Machines. **Sensors**: Proximity and position sensors, velocity sensors, Motion sensors, Acceleration sensors, Pressure sensors, Torque Sensors. **Signal Conditioners:** Need of isolators, filters, amplifiers, fluid and optical amplifiers, Data converters in Mechatronic system.	
Module – 2	**08 Hrs**
Basic Mechatronics System: Basic System Models: Introduction, Mechanical system building blocks-Translational and Rotational system building up a mechanical system model, Electrical system building blocks-Building up model. **System Models:** Introduction, rotational translational systems, Electromechanical systems. **CNC Machines:** General configuration, advantages, Part programming of CNC machines, G codes and M codes, small application programs, CNC based drilling machine.	
Module – 3	**08 Hrs**
Mechatronics in Mobility: Need of mechatronics in automobiles. modelling and simulation antilock braking system – power steering – adaptive cruise control – active suspension system – case studies in vehicle communication - Hybrid EV- electronic ignition – engine control system – tyre pressure monitoring system -Ornithopter – Intelligent cockpit electronics – Digital flyby wire systems- longitudinal and later control design – surveillance drone –Navigation – Robotic arm in International Space station- Magnetic levitation system.	
Module – 4	**08 Hrs**

Mechatronics in Manufacturing: Computed aided metrology –monitoring and control in manufacturing process - case studies in additive manufacturing - case studies in advanced machining-case studies in automated production line - AGV - simultaneous localization and mapping (SLAM) -virtual manufacturing -internet controlled manufacturing - SMART FACTORY, ASRS, mobile manipulator.	
Module – 5	**08 Hrs**
Mechatronics in others Application: Surgical Robot - Skeletal muscles servo mechanism – Analysis of force in orthopedic implants – sensory assisted exoskeletons – lower and upper limb exoskeleton- Rehabilitation, wheelchairs for mobility assistance - Haptics- online patience monitoring - Applications in sports and exercise. Intelligent safety elements in buildings - robotics in construction – IoT assisted home automation- Bio Mimics.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Define and explain design process
CO2	Explain Mechatronics systems and models
CO3	Build a mechatronics system for mobility applications
CO4	Apply the concept of Mechatronics in manufacturing
CO5	Apply the concept of Mechatronics in construction and bio mimics robot

Text Books	
1	William Bolton, “Mechatronics: Electronic Control Systems In Mechanical and Electrical Engineering”,7th edition, Pearson. 2023
2	Robort H Bishop, “Mechatronics an Introduction”, Taylor and Francis, 2nd edition, 2003
3	Annalisa Melilla, Donato Di Paola and Grazia Cicirelli, “Mechatronic Systems, Applications”, InTech publisher, 2010.
4	Devdasshetty, Richard A. Kolkm, “Mechatronics System Design”, PWS Publishing company, 2nd edition,2010.

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**1**	**1**	**2**		**1**	**1**
CO2	**2**	**2**	**1**	**3**		
CO3	**1**	**2**	**1**		**3**	
CO4	**1**	**2**	**1**		**2**	**3**
CO5	**2**	**1**	**2**	**2**		**3**

Semester: I						
Engineering Computational Tools Laboratory						
Course Code	:	**MMEL106**		**Credits**	:	02
Hours/Week (L:T:P)	:	0:0:4		**CIE**	:	50 Marks
Total Hours	:	40		**SEE**	:	50 Marks
Course Type	:	PCCL		**SEE Duration**	:	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To conduct experimental and numerical analysis of tensile test and flexural test.
CLO2	To conduct numerically analysis and MATLAB Simulation of principal stresses and principal strains
CLO3	To conduct experiment on stress concentration and contact stresses.
CLO4	To conduct experimental and numerical analysis four point bending and torsion of prismatic bar.
CLO5	To determine the vibrational characteristics of Spring Mass Damper System, Analytically and simulate the results using MATLAB.

List of Experiments		
Sl. No	**Name of Experiment**	
1	Experimental and Numerical Analysis of Tensile Test	Part A: Experimental study of Tensile Test
		Part B: Numerical Analysis of Tensile Test
2	Experimental and Numerical Analysis of Flexural Test	Part A: Experimental study of Flexural Test
		Part B: Numerical Analysis of Flexural Test
3	Numerically Calculation and MATLAB Simulation	Part A: Invariants, Principal stresses and strains with directions
		Part B: Maximum shear stresses and strains and planes, Von-Mises stress.
		Part C: Calculate and Plot Stresses in Thick-Walled Cylinder
4	Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. Shear	Part A: MATLAB simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate
		Part B: Modeling of plate geometry under chosen load conditions and study the effect of plate geometry
		Part C: Numerical Analysis using FEA package
5	Single edge notched beam in four-point bending	Part A: Modeling of single edge notched beam in four point bending
		Part B: Numerical Studies using FEA
		Part C: Correlation Studies
6	Torsion of Prismatic bar with	Part A: Elastic solutions, MATLAB Simulation

	Rectangular cross-section	Part B: Finite Element Analysis of any chosen geometry.
		Part C: Correlation studies.
7	Contact Stress Analysis of Circular Disc under diametrical compression	Part A: 3-D Modeling of Circular Discs with valid literature background, supported with experimental results on contact stress
		Part B: Numerical Analysis using any FEA package
		Part C: 2D Photo Elastic Investigation
8	Vibration Characteristics of a Spring Mass Damper System	Part A: Analytical Solutions
		Part B: MATLAB Simulation
		Part C: Correlation Studies

Course Outcomes: After completing the course, the students will be able to	
CO1	Experimentally and numerically analyze the tensile, bending and torsion tests.
CO2	Validate the analytical results using MATLAB.
CO3	Conduct stress analysis.
CO4	Analytically and numerically analyze the vibration characteristics of spring mass damper

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**2**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**3**	**3**	**3**
CO3	**3**	**2**	**3**	**2**	**2**	**2**
CO4	**3**	**2**	**3**	**2**	**2**	**2**

Semester: I						
Theory of Metal Cutting and forming						
Course Code	**:**	**MME104A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To understand basics of metal cutting and metal forming
CLO2	To understand various factors of machining
CLO3	To understand the process of various forming methods.
CLO4	To practically study and practice the machining and forming methods

Module – 1	**08 Hrs**
Introduction to metal cutting: Mechanism of chip formation, Orthogonal & Oblique cutting, types of chips, built-up edge, Determination of shear plane angle, forces on the chips, forces in orthogonal cutting, Merchant circle diagram and analysis, effect of cutting parameters on tool geometry. Characteristics of tool materials, types of tool materials – carbon tool steels, high speed steels, cast alloys, cemented carbides, ceramics, diamonds, SIALON, CBN, UCON Mechanisms of tool wear, Sudden & gradual wear, crater wear, flank wear, tool failure criteria, tool life equations, effect of process parameters on tool life.	
Module – 2	**08 Hrs**
Force measurements: Reasons for measuring cutting forces, Classification of cutting force dynamometers – mechanical, hydraulic, pneumatic, optical, inductance, piezoelectric, and strain gage type dynamometers. **Temperature measurements**: Heat sources in metal cutting, temperature in chip formation, temperature distribution, and experimental determination of tool temperatures. **Advanced Machining** Techniques: cryo machining and high-speed machining its defects and remedies.	
Module – 3	**08 Hrs**
Introduction to metal forming: Effect of temperature on forming process-hot working, cold working. Effect of Metallurgical structure, Effect of speed of deformation work of Plastic deformation, Friction in forming operation. Concept of true stress and true strain, uniaxial, biaxial, triaxial stresses, Von-mises criteria, tresca criteria, principle stresses concepts of plane stress and plane strain.	
Module – 4	**08 Hrs**

Forging: Classification, various stages during forging, Forging equipment, brief description, deformation in compression, forging of slabs, discs with respect to sticking, sliding and mixed friction forging defects. **Rolling**: Classification, forces and geometrical relationships in rolling. Expression for rolling load, roll separating force and rolling defects
Module – 5 **08 Hrs**
Extrusion: Classification, Extrusion equipment, variables in extrusion, Deformation in extrusion, Extrusion defects, **Drawing**: Principles of Rod and wire drawing, variables in wiredrawing, Residual stresses in rod, wire and tube drawing, Defects in Rod and wire drawing

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the Basics of Metal Cutting and Forming
CO2	Explore Various Machining Forces and Measuring Instruments
CO3	Apply the Practical Aspects of Machining and Forming
CO4	Analyze the various Parameters in Machining and Forming

Web links and Video Lectures (e-Resources)	
1	VTU e-Shikshana Program VTU EDUSAT Program
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Seminars
2	Assignments

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		**3**	**3**			**3**
CO2	**2**			**2**	**2**	
CO3			**2**		**2**	
CO4	**2**	**2**	**3**		**3**	**1**

Semester: I						
Material Selection in Machine Design						
Course Code	**:**	**MME104B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To develop advanced understanding on the basic concepts and methodology of material selection in mechanical design.
CLO2	To understand how to use diverse engineering materials property data to select appropriate materials for structural applications in a variety of engineering contexts..
CLO3	To use engineering materials property data to justify the selection of materials, processes and component geometry against various design goals.

Module – 1	**08 Hrs**
Introduction: Materials in design, The evolution of engineering materials. Case Study: Vacuum cleaner. **Design Process:** The design process, Types of design, Design tools and materials data, Function, material, shape, and process	
Module – 2	**08 Hrs**
Engineering Materials and their Properties: The families of engineering materials, The definitions of material properties, Exploring material properties and charts **Materials Selection:** The selection strategy, Attribute limits and material indices, Selection procedure, Computer-aided selection. **Case Studies:** Materials for springs, heat exchangers, thermal distortion in precision devices, Radomes in Aircrafts.	
Module – 3	**08 Hrs**
Processes and Process Selection: Classifying processes, The processes: shaping, joining, and finishing, Systematic process selection, Computer-aided process selection **Multiple constraints and objectives:** Selection with multiple constraints, Conflicting objectives, penalty-functions, and exchange constants	
Module – 4	**08 Hrs**
Designing Hybrid Materials: Filling holes in material-property space, The method: A + B +Configuration + Scale. Composites: Hybrids of type 1, Sandwich structures: Hybrids of type 2, Lattices: hybrids of type 3, Segmented structures: Hybrids of type 4 **Case studies: Efficiency of** Natural materials, Designing metal matrix composites, Refrigerator walls, Extreme combinations of thermal and electrical conduction, The mechanical efficiency of natural materials	
Module – 5	**08 Hrs**

Materials and the Environment: The material life cycle, Material and energy-consuming systems, The eco-attributes of materials, Eco-selection **Materials and Industrial Design**: The requirements pyramid, Product character, Using materials and processes to create product personality.

Course Outcomes: After completing the course, the students will be able to	
CO1	Use materials property charts, to apply engineering and science principles, to make initial judgements about the selection of materials for diverse engineering design contexts.
CO2	Apply engineering and science principles to understand a broad range of processes for materials manufacture and their implications for materials and process selection.
CO3	Apply engineering and science principles to analyse the mechanics of a materials design problem so as to select materials and geometry to minimise weight, minimize environmental impact, etc.
CO4	Analyse complex problems in order to establish when a hybrid material might provide a better design solution than a monolithic engineering material.

Text Books	
1	Materials Selection in Mechanical Design, Third Edition by Michael F. Ashby
2	A History of Technology (21 volumes), edited by Singer, C., Holmyard, E.J., Hall, A.R., Williams,T.I., and Hollister-Short, G. Oxford University Press (1954–2001)
3	Cross, N. (2000) Engineering Design Methods, 3rd edition, Wiley, Chichester, UK. ISBN 0-471-87250-4. (A durable text describing the design process, with emphasis on developing and evaluating alternative solutions.)
4	ASM Engineered Materials Handbook (2004) "Testing and characterization of polymeric materials", ASM International, Metals Par

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1		**3**				**3**
CO2	**3**			**3**		
CO3			**3**		**3**	
CO4	**2**	**2**	**3**			**3**

Semester: I						
Advanced Fluid Mechanics						
Course Code	**:**	**MME104C**		**Credits**	**:**	03
Hours/Week (L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To understand the kinematics of fluids, their governing equations, Mechanics of laminar and turbulent flow, NS Equations.
CLO2	Advanced knowledge of boundary layer equation, as well as a fundamental understanding of the drag and lift force.
CLO3	Understanding of the fundamental of the Flow across Normal Shock and Oblique Shock and Comparison of isentropic and adiabatic processes.
CLO4	Knowledge of several practical applications of the theory covered.

Module – 1	**08 Hrs**
Review of undergraduate Fluid Mechanics: Introduction: Fluid Statics, Relative Motion of Liquids. Kinematics of Fluids- Review of basics-Velocity potential, Stream function and Vorticity. Fundamental Equations, Applications of Fundamental Equations, Differential Flow analysis- Continuity equation (3D Cartesian, Cylindrical and spherical Coordinates) Navier Stokes equations (3D- Cartesian, coordinates), Energy Equations (3D- Cartesian, coordinates), Elementary in viscid flows; superposition (2D).	
Module – 2	**08 Hrs**
Mechanics of Laminar and Turbulent Flow: Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number - wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus. structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equation model for fully turbulent flows and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.	
Module – 3	**08 Hrs**
Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen 's approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow. **Boundary layer over a flat plate:** Thickness of boundary layer, displacement and momentum thickness, Prandtl's boundary layer equation, Vonkarmann momentum equation – shear stress and drag force, laminar boundary layer, turbulent boundary layer, pressure distribution in the boundary layer, boundary layer separation, drag and lift force – lift on an airfoil.	
Module – 4	**08 Hrs**
Energy equation: Energy equation for non-flow and flow processes, adiabatic energy equation, stagnation enthalpy, stagnation temperature, stagnation pressure, stagnation velocity of sound, reference velocities, Bernoulli's equation, effect of Mach number on compressibility. **Isentropic Flow with variable Area:** Comparison of isentropic and adiabatic processes, Mach Number variation, Stagnation and critical states, Area ratio as a function of Mach number, impulse function, Mass flow rate, Flow through nozzles and diffusers.	
Module – 5	**08 Hrs**

Flow across Normal Shock and Oblique Shock: Development of a shock wave, rarefaction wave, governing equations, Prandtl-Meyer relation, Mach number downstream of the shock wave, static pressure ratio, temperature ratio, density ratio, and stagnation pressure ratio across the shock. Oblique shock waves fundamental relations, Prandtl's Equation, Rankine – Hugoniot Equation, Variation of flow parameters, Relations and Tables, Numerical Problems.

Course Outcomes: After completing the course, the students will be able to	
CO1	Illustrate the basic concepts fluid flow and their governing equations
CO2	Analyze the laminar and turbulent flow problems.
CO3	Demonstrate the concept of boundary layer equations and drag and lift force
CO4	Distinguish normal and oblique shocks and their governing Equations.
CO5	Explain the Propagation of sound waves and Comparison of isentropic and adiabatic processes in fluid mechanics.

Text Books	
1	Foundations of fluid mechanics - S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India, 2000.
2	White F.M., Viscous Fluid Flow, 3rd edition, Tata McGraw Hill Book Company, 2011.
3	S.M. Yahya, Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion (SI UNITs), Fifth Edition, New Age International Publishers, New Delhi, 2020.

Reference Books	
1	Yunus A. Cengel and John M. Cimbala, Introduction to Fluid Mechanics, Second Edition, Tata McGraw-Hill, 2010.
2	Introduction to fluid dynamics - Principles of analysis & design - Stanley Middleman, Wiley,1997.
3	SD. S. Kumar, Fluid Mechanics and Fluid power engineering, S. K. Kataria & sons, 2010.

Web links and Video Lectures(e-Resources):	
1	https://archive.nptel.ac.in/courses/112/105/112105218/
2	https://archive.nptel.ac.in/courses/112105269/
3	https://archive.nptel.ac.in/courses/112/105/112105287/

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**2**	**1**			**1**
CO2	**3**	**2**	**1**	**2**		**1**
CO3	**3**	**2**	**1**	**2**		**1**
CO4	**3**	**2**	**1**	**2**		**1**
CO5	**3**	**2**	**1**			**1**

Semester: I						
Design of Experiments						
Course Code	**:**	**MME104D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To develop an understanding of experimental methods and major experimental designs and think critically about their proper application.
CLO2	Write hypotheses that can be tested using experiments.
CLO3	Be able to develop different types of experimental designs

Module – 1	**08 Hrs**
Introduction: Strategy of Experimentation, Typical applications of Experimental design, Basic Principles, Guidelines for Designing Experiments.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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,	
Module – 4	**08 Hrs**
Measures of variability, Ranking method, Column effect method & Plotting method, Analysis of variance (ANOVA) in Factorial Experiments: YATE's algorithm for ANOVA.	
Module – 5	**08 Hrs**
Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the fundamentals of experiments and its uses
CO2	Apply of statistical models, ANOVA in analysing experimental data
CO3	Analyze the data and identify the significant factors which influence the results

CO4	Create sample data analysis using any DOE concepts

Text 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/

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**3**	**1**	**3**	**1**	**2**
CO2	**3**	**3**	**1**	**3**	**1**	**2**
CO3	**3**	**3**	**1**	**3**	**1**	**2**
CO4	**3**	**3**	**2**	**2**	**3**	**3**

Semester: I						
Additive Manufacturing Techniques						
Course Code	**:**	MME105A		**Credits**	**:**	04
Hours/Week (L:T:P)	**:**	3:2:0		**CIE**	**:**	50 Marks
Total Hours	**:**	50		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Develop a comprehensive understanding of fundamental additive manufacturing– alternatively, "three-dimensional (3D) printing" – approaches, including extrusion- based deposition, stereo lithography, powdered – based melting, and inkjet based deposition.
CLO2	Cultivate a "design -for- additive manufacturing" skill set for combining computer-aided design (CAD) and computer-aided manufacturing (CAM) methodologies to produce successful 3D prints.
CLO3	Fabricate 3D mechanical objects using a variety of 3D printing technologies on campus.
CLO4	Execute a design project that demonstrates how additive manufacturing technologies can overcome critical limitation soft traditional manufacturing processes.

Module – 1	**10 Hrs**
Introduction and Basic Principles: The Generic AM Process and its Benefits. Distinction between AM and CNC Machining. Example of AM Parts and other Related Technologies. **Development of Additive Manufacturing Technology**: Computer-Aided Design Technology and Other Associated Technologies. The Use of Layers. Metal Systems and Hybrid Systems	
Module – 2	**10 Hrs**
Generalized Additive Manufacturing Process Chain: Introduction. Steps in Additive Manufacture, Variations from One AM Machine to Another. Maintenance of Equipment and Materials Handling Issues. **Vat Photo polymerization Processes:** Introduction, Reaction Rates, Laser Scan Vat Photo-polymerization, Photo polymerization Process Modelling, Vector Scan VP Machines, Scan Patterns. Vector Scan Micro-Vat Photo polymerization. Process Benefits and Drawbacks	
Module – 3	**10 Hrs**
Extrusion-Based Systems: Introduction, Basic Principles, Material Loading Liquefaction, Extrusion, Solidification, Positional Control, Bonding, Support Generation Plotting and Path Control. FDM Machine. Types, Materials, Limitations of FDM. Bio-Extrusion and Other Systems **Material Jetting:** Materials for Material Jetting, Materials for Material Jetting, MJ Process Modelling, Material Jetting Machines, Process Benefits and Drawbacks	
Module – 4	**10 Hrs**
Design for Additive Manufacturing: Motivation, Design for Manufacturing and Assembly, AM Unique Capabilities. Shape Complexity. Hierarchical Complexity. Functional Complexity Material Complexity Core DFAM Concepts and Objectives Complex Geometry Integrated Assemblies Customized Geometry Multifunctional Designs Elimination of Conventional DFM Constraints Contents Exploring Design Freedoms Part Consolidation and Redesign Hierarchical Structures Industrial Design Applications. **Rapid Tooling:** Introduction Direct AM Production of Injection Moulding Inserts EDM Electrodes Investment Casting Other Systems Vacuum Forming Tools Paper Pulp Moulding Tools Formwork for Composite Manufacture Assembly Tools And Metrology Registration Rigs	

Module – 5	10 Hrs
Applications for Additive: Manufacture Introduction Historical Developments Value of Physical Models Functional Testing Rapid Tooling The Use of AM to Support Medical Applications Surgical and Diagnostic Aids Prosthetics Development Manufacturing Tissue Engineering and Organ Printing Software Support for Medical Applications **Limitations of AM**: Limitations of AM for Medical Applications Speed Accuracy Materials Ease of Use Further Development of Medical AM Applications Approvals Insurance Engineering Training Location of the Technology Service Bureaus Aerospace Applications Characteristics Favouring AM Production Manufacture Automotive Applications	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the importance and growth of Rapid Prototyping Techniques.
CO2	Differentiate and describe the operation, applications and advantages of Stereo lithography, selective Laser sintering and fused deposition modelling.
CO3	Analyze solid ground curing and laminated object manufacturing processes and their working.
CO4	Evaluate different Concept Model less and recommend different tooling requirements for Rapid Prototype

Text Books	
1	Pham D.T.& DimovS.S"RapidManufacturing"SpringerLondon2011.2.
2	C.P.Paul&A.N.Jinoop,“AdditiveManufacturing:Principles,TechnologiesandApplications”, McGrawHill2021.
3	TerryWohlers"Wohler'sReport2000"Wohler'sAssociation2000
4	PaulF.Jacobs:"StereolithographyandotherRP&MTechnologies",SME,NY1996,Springer

Web links and Video Lectures(e-Resources):	
1	https://youtu.be/t7yv4gSnNkE?list=PLwdnzlV3ogoWI8QEu4hsT-n_r8UbWbquy
2	https://youtu.be/Bwog2XYCmN8

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**2**	**1**	**2**	**2**	**2**
CO2	**3**	**2**	**1**	**2**	**2**	**1**
CO3	**3**	**2**	**1**	**2**	**2**	**1**
CO4	**3**	**2**	**1**	**2**	**1**	**1**

Semester: I						
Smart Mobility						
Course Code	:	**MME105B**		**Credits**	:	03
Hours/Week(L:T:P)	:	3:0:0		**CIE**	:	50 Marks
Total Hours	:	40		**SEE**	:	50 Marks
Course Type	:	PEC		**SEE Duration**	:	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To deliver and discuss the about architecture, power electronics-based drive control systems, battery management systems and grid integration issues of Electric and Hybrid vehicles.

Module – 1	**08 Hrs**
Introduction to Electric Vehicle (EV) & Hybrid Vehicle (HV): Air pollution and global warming, Impact of different transportation technologies on environment and energy supply, A brief history of Electric and Hybrid Vehicles, Basic Architecture of Hybrid Drive Train and Analysis of Series Drive Train, Vehicle Motion and the Dynamic Equations for the Vehicle, Types of HV and EV, Advantages Over Conventional Vehicles, limitations of EV and HV, Impact on Environment of EV and HV technology, Disposal of Battery, Cell and Hazardous Material and their Impact on Environment.	
Module – 2	**08 Hrs**
Power Management and Energy Sources of EV and HV: Power and Energy management Strategies and its General Architecture of EV and HV, Various Battery Sources, Energy Storage, Battery Based Energy Storage and Simplified Models of Battery, Battery Management Systems (BMS), Fuel Cells, their Characteristics and Simplified Models, Super Capacitor Based Energy Storage, its Analysis and Simplified Models, Flywheels and their Modeling for Energy Storage in HV/BEV, Hybridization of Various Energy Storage Devices, Selection of the Energy Storage Technology.	
Module – 3	**08 Hrs**
Power Electronics in EV & HV: Introduction, Various Power Electronics Converter Topologies and its Comparisons, Control of convertor operations in EV and HV, battery chargers used in EV & HV, Emerging Power Electronic Devices. **DC and AC Machines & Drives in EV & HV:** Various types of Motors, Selection and Size of Motors, Induction Motor Drives and Control Characteristics, Permanent Magnet Motor Drives and Characteristics, Brushed & Brushless DC Motor Drive and Characteristics, Switched Reluctance Motors and Characteristics, IPM Motor Drives and Characteristics, Mechanical and Electrical Connections of Motors.	
Module – 4	**08 Hrs**
Components & Design Considerations of EV & HV: Design Parameters of Batteries, Ultra-Capacitors and Fuel Cells, Aerodynamic Considerations, Calculation of the Rolling Resistance and the Grade Resistance, Calculation of the Acceleration Force, Total Tractive Effort, Torque Required on the Drive Wheel, Transmission Efficiency, Consideration of Vehicle Mass, Electric Vehicle Chassis & Body Design, General Issues in Design, Specifications and Sizing of Components	
Module – 5	**08 Hrs**

Electric and Hybrid Vehicles and Grid Interconnection Issues:
Introduction to Smart Charging: Grid to Vehicle and Vehicle to Grid, Smart Metering and Ancillary Services, Preliminary Discussion on Vehicle to Vehicle and Vehicle to Personal Communication Systems, Introduction to Battery Charging Stations and Its Installation and Commissioning, Preliminary Discussion on Estimation on Station Capacity and Associated Technical Issues, Different Connectors, Policy Regulations and Standards for EV and HV, BEE Standards, Indian And Global Scenario, Case Studies.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the architecture and vehicle dynamics of electric and hybrid vehicles
CO2	Analyze and model the power management systems for electric and hybrid vehicles
CO3	Devise power electronics-based control strategies for electric and hybrid vehicles
CO4	Analyze and design various components of electric and hybrid vehicles with environment concern.
CO5	Investigate and model the issues in mathematical domain related to grid interconnections of electric and hybrid vehicle.

Text Books	
1	Iqbal Hussain, “Electric and Hybrid Vehicles Design Fundamentals”, 1st Edition, CRC Press, 2003.
2	James Larminie, John Lowry “Electric Vehicle Technology Explained”, 1st Edition, John Wiley and Sons, 2003.
3	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4	Chris Mi, M. Abul Masrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, Wiley publication, 2011.
5	Allen Fuhs, “Hybrid Vehicles and the future of personal transportation”, CRC Press, 2009.
Skill Development Activities Suggested	
1	Study and analysis of different topologies used in electrical and hybrid vehicles
2	Simulation and analysis of Induction motor characteristics used for electric vehicle
3	Simulation and analysis of BLDC motor characteristics used for electric motor vehicle
4	Simulation and analysis of Switch Reluctance motor characteristics used for electric motor vehicle
5	Simulation and analysis of IPMSM motor characteristics used for electric motor vehicle

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**2**		**3**	
CO2	**2**	**2**	**2**	**3**		**3**
CO3	**2**	**2**	**2**		**3**	
CO4	**2**	**2**	**2**	**3**		
CO5	**2**	**2**	**2**			**3**

Semester: I						
Introduction to AI and ML						
Course Code	**:**	**MME105C**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understands the basics of AI, history of AI and its foundations, basic principles of AI for problem solving.
CLO2	Explore the basics of Machine Learning & Machine Learning process, understanding data
CLO3	Understand the Working of Artificial Neural Networks.

Module – 1	**08 Hrs**
Introduction: What is AI, The foundation of Artificial Intelligence, The history of Artificial Intelligence, Intelligent Agents: Agents and Environments, Good Behaviour: The concept of rationality, the nature of Environments, the structure of Agents.	
Module – 2	**08 Hrs**
Problem solving by searching: Problem solving agents, Example problems, Searching for solutions, Uniformed search strategies, Informed search strategies, Heuristic functions.	
Module – 3	**08 Hrs**
Introduction to machine learning: Need for Machine Learning, Machine Learning Explained, and Machine Learning in relation to other fields, Types of Machine Learning. Challenges of Machine Learning, Machine Learning process, Machine Learning applications.	
Module – 4	**08 Hrs**
Understanding Data: What is data, types of data, Big data analytics and types of analytics, Big data analytics framework, Descriptive statistics, univariate data analysis and visualization Bivariate and Multivariate data, Multivariate statistics, Essential mathematics for Multivariate data, Overview hypothesis, Feature engineering and dimensionality reduction techniques. **Similarity-based learning:** Introduction to Similarity or instance based learning, Nearest neighbor learning, weighted k- Nearest - Neighbor algorithm.	
Module – 5	**08 Hrs**
Artificial Neural Network: Introduction, Biological neurons, Artificial neurons, Perceptron and learning theory, types of Artificial neural Network, learning in multilayer Perceptron, Radial basis function neural network.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Design intelligent agents for solving simple gaming problems.
CO2	Have a good understanding of machine leaning in relation to other fields and fundamental issues and Challenges of machine learning
CO3	Understand data and applying machine learning algorithms to predict the outputs.
CO4	Model the neuron and Neural Network, and to analyze ANN learning and its applications.

Text Books	
1	Stuart Russel, Peter Norvig: "Artificial Intelligence-A Modern approach", 3rd Edition, Pearson Education, 2015.
2	S Sridhar, M Vijayalakshmi: "Machine Learning", Oxford, 2021.
3	Elaine Rich, Kevin Knight: "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2009,ISBN-10: 0070087709.

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**1**		**2**	**1**
CO2	**2**	**2**	**1**	**2**	**1**	**1**
CO3	**2**	**2**	**1**			**1**
CO4	**2**	**2**	**1**	**2**	**1**	**1**

Semester: I						
Industrial Robotics						
Course Code	**:**	**MME105D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	The goal of the course is to familiarize the students with the concepts and techniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.
CLO2	Make the students acquainted with the theoretical aspects of Robotics
CLO3	Enable the students to acquire practical experience in the field of Robotics through design projects and case studies.
CLO4	Make the students to understand the importance of robots in various fields of engineering.

Module – 1	**08 Hrs**
Introduction: Automation and Robotics – An over view of Robotics – present and future applications. Components of the Industrial Robotics: common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, Design of end effectors, Precision of Movement: Resolution, Accuracy and Repeatability, Speed of Response and Load Carrying Capacity.	
Module – 2	**08 Hrs**
Motion Analysis: Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation – problems. Manipulator Kinematics-H notation-H method of Assignment of frames-H Transformation Matrix, joint coordinates and world coordinates, Forward and inverse kinematics – problems on Industrial Robotic Manipulators.	
Module – 3	**08 Hrs**
Differential transformation of manipulators, Jacobians – problems. Dynamics: Lagrange – Euler and Newton –Euler formations – Problems. Trajectory planning and avoidance of obstacles, path planning, Slew motion, joint interpolated motion straight line motion.	
Module – 4	**08 Hrs**
Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors, Tactile and Range sensors, Force and Torque sensors – End Effectors and Tools	
Module – 5	**08 Hrs**
Robot Application in Manufacturing: Material Transfer – Material handling, loading and unloading- Processing – spot and continuous arc welding & spray painting – Assembly and Inspection. Robotic Programming Methods – Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.	

Course Outcomes: After completing the course, the students will be able to	
CO1	To understand the basic components of robots.
CO2	Differentiate types of robots and robot grippers.
CO3	Model forward and inverse kinematics of robot manipulators.
CO4	Analyze forces in links and joints of a robot.
CO5	Programme a robot to perform tasks in industrial applications.

Text Books	
1	Industrial Robotics / Groover M P /Mc Graw Hill
2	Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson
Web links and Video Lectures (e-Resources):	
1	VTU e-Shikshana Program
2	VTU EDUSAT Program

CO – PO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**2**	**2**	**3**	**3**	**3**	**2**
CO2	**2**	**2**	**3**	**3**	**3**	**3**
CO3	**3**	**2**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**2**	**2**	**2**	**2**
CO5	**2**	**2**	**2**	**3**	**3**	**3**

II SEMESTER (Core Courses related to main Engineering Stream)

Sl. No	Course Type	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical/Seminar	Tutorial/SDA	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	T/SDA					
1	IPCC	MME201	Advanced Finite Element Methods and Applications	3	2	0	05	50	50	100	4
2	PCC	MME202	Modern Vibration Theory and Application	3	0	0	03	50	50	100	3
3	PCC	MME203	Advanced Machine Design	3	0	0	03	50	50	100	3
4	PEC	MME204x	Professional Elective 3	3	0	0	03	50	50	100	3
5	PEC	MME205x	Professional Elective 4	3	0	0	03	50	50	100	3
6	PCCL	MME206	Mechanics of Composite Materials	3	0	0	03	50	50	100	2
7	PCC	MMEL207	Mechanical Simulation Laboratory	0	4	0	02	50	50	100	2
7	AEC/SEC	MME208x	Ability Skill Enhancement Course (Offline)	-	-	2	2	50	50	100	1
Total				**18**	**6**	**2**	**24**	**400**	**400**	**800**	**22**

Professional Elective III		Professional Elective IV	
MME204A	Optimization Techniques	MME205A	Mechanical Behavior of Materials
MME204B	Fatigue and Fracture Mechanics	MME205B	Basics of Machine Learning
MME204C	Sustainability Engineering	MME205C	Design for Manufacturing and Assembly
MME204D	Signal analysis and condition monitoring	MME205D	Design of Aerospace structures
MME204E	Digital manufacturing	MME205E	Introduction to Hybrid and Electric Vehicles

Note: **PCC**: Professional core. **IPCC**-Integrated Professional Core Courses, **PCC(PB):** Professional Core Courses (Project Based), **PCCL**-Professional Core Course lab**, PEC-** Professional Elective Courses, **MDC**- Multi-Disciplinary Courses

L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities)

Course Code	Course Type	L	T/SDA	P
MME208A	Numerical Programming for Mechanical Engineers (Using MATLAB/NumPy)	-	2	-
MME208B	Python Programming for Beginners	--	2	--
MME208C	Multi-Body Simulation using VTU's CoE Software	--	2	--
MME208D	3D Printing and Robotic Simulation Programming	--	2	--

Semester: II						
ADVANCED FINITE ELEMENT METHODS AND APPLICATIONS						
Course Code	**:**	**MME201**		**Credits**	**:**	04
Hours/Week(L:T:P)	**:**	3:2:0		**CIE**	**:**	50 Marks
Total Hours	**:**	50		**SEE**	**:**	50 Marks
Course Type	**:**	IPCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**YES**

Course Learning Objectives: This course will enable the students to	
CLO1	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.
CLO2	Discuss the use of finite element methods in engineering problem-solving drawing from applications in solid mechanics and other engineering Domains.
CLO3	Familiarize students with professional-level finite element software.
CLO4	To define, derive and assemble stiffness matrices for spring element, truss element, beam elements, Plane Stress element.
CLO5	To be familiar with the idea of Isoparametric formulation for various FE Elements
CLO6	FE Formulation of Axisymmetric and Solid Elements.

Module – 1	**10 Hrs**
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.	
Module – 2	**10 Hrs**
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, 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.	
Module – 3	**10 Hrs**
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.	

Module – 4	**10 Hrs**
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.	
Module – 5	**10 Hrs**
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 without stiffness matrix derivation)	

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: $\frac{\partial^2u}{\partial x^2}+\frac{\partial^2u}{\partial y^2}=0$ 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 generalized 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 (For CIE)	
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.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the Basis of formulation of Finite Element Methods.
CO2	Formulate the complete FE Formulation for 1D, 2D, and 3D Elements.
CO3	Evaluate various boundary conditions in the FE Application.
CO4	Write a small computer program to analyze a simple Truss structure.

Text 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 Analyze 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 summaries the format of the input ASCII files generated by commercial meshing software for any well know FE Solver.

CO – PO MAPPING

	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

Semester: II						
MODERN VIBRATION THEORY AND APPLICATION						
Course Code	**:**	MME202		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To study the basic concepts of vibration
CLO2	To characterize the free and forced vibrations of damped and undamped single degree of freedom systems.
CLO3	To understand the transient vibration response of a single degree of freedom system.
CLO4	To study various vibration measuring instruments.
CLO5	To study and characterize the random vibrations.
CLO6	To characterize the continuous systems.
CLO7	To study the basic principles of maintenance and condition monitoring.

Module – 1	**08 Hrs**
Introduction to vibrations, Importance of studying vibrations, **Types of vibrations**: Free and Forced, Damped and Undamped. **Basic concepts**: Periodic motion, Harmonic motion, Vibration Terminology.	
Module – 2	**08 Hrs**
FREE VIBRATION: Vibration Model, Equation of Motion: Natural Frequency, Energy Method, Rayleigh Method: Effective Mass, Principle of Virtual Work, Viscously Damped Free Vibration, Logarithmic Decrement	
Module – 3	**08 Hrs**
HARMONICALLY EXCITED VIBRATION: Forced Harmonic Vibration, Rotating Unbalance, Rotor Unbalance, Whirling of Rotating Shafts, Support Motion, Vibration Isolation, Energy Dissipated by Damping, Equivalent Viscous Damping, Structural Damping, Sharpness of Resonance, Vibration- Measuring Instruments	
Module – 4	**08 Hrs**
Introduction: Transverse Vibration of a String or Equation of Motion, Initial and Boundary Conditions, Free Vibration of a Uniform String, Free Vibration of a String with Both Ends Fixed, Traveling-Wave Solution. **Longitudinal Vibration of a Bar or Rod:** Equation of Motion and Solution, Orthogonality of Normal Functions. **Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams :** Equation of Motion, Initial Conditions, Free Vibration, Boundary Conditions.	
Module – 5	**08 Hrs**

Introduction,Transducers: Variable Resistance Transducers, Piezoelectric Transducers, Electrodynamics Transducers, Linear Variable Differential Transformer Transducer.
Vibration Pickups: Vibrometer, Accelerometer, Velometer, Phase Distortion.
Frequency-Measuring Instruments Vibration Exciters: Mechanical Exciters, Electrodynamic Shaker,
Signal Analysis: Spectrum Analyzers, Bandpass Filter, Constant-Percent Bandwidth and Constant-Bandwidth Analyzers.
Dynamic Testing of Machines and Structures: Using Operational Deflection-Shape Measurements, Using Modal Testing,.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the basics of vibrations and determine the equations of motion for free & forced vibrations of single degree of freedom systems and to find their solution.
CO2	Determine the response of a single degree of freedom system subjected to various types of input forces.
CO3	Apply fundamentals of vibrations to its measurement and analysis.
CO4	Determine the equations of motion for continuous system and to find their solutions.
CO5	Understand the basic concepts of maintenance and to apply these concepts for condition monitoring of machines.

Text Books	
1	William T. Thomson and Marie Dillon Dahleh, Theory of Vibration with Applications, Pearson Education
2	Singiresu S. Rao, Mechanical Vibrations, Pearson Education
3	Leonard Meirovitch, Fundamentals of Vibrations, McGraw-Hill
4	Daniel J. Inman, Engineering Vibration, Pearson Education
5	S. Timoshenko, Vibration Problems in Engineering, Wiley

Reference Books	
1	S. Graham Kelly, Fundamentals of Mechanical Vibrations, McGraw-Hill
2	Anil Rao, Mechanical Vibrations and Noise Engineering, Pearson
3	Clive D. Rodgers, Modal Testing: Theory, Practice, and Application, Wiley

Skill Development Activities Suggested	
1	Write MATLAB/ SCILAB programs to simulate the response of single degree of freedom systems under free and forced vibrations.
2	To create mathematical models of single degree of freedom systems in MATLAB Simulink /SCILAB.

CO – PO MAPPING

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

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

Semester: II						
ADVANCED MACHINE DESIGN						
Course Code	**:**	**MME203**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Outline the basic philosophy of machine design
CLO2	Compute the required load under various practical conditions
CLO3	Apply the various static load based theories of failures
CLO4	Apply the various fatigue load based theories of failures

Module – 1	**08 Hrs**
Introduction to Mechanical Engineering Design: Design and Mechanical Engineering Design, Phases and Interactions of the Design Process, Design Tools and Resources, The Design Engineer's Professional Responsibilities, Standards and Codes, Stress and Strength, Design Factor and Factor of Safety, Reliability, Dimensions and Tolerances, Calculations and Significant Figures.	
Module – 2	**08 Hrs**
Load Determination: Loading Classes, FBDs, Load Analysis, 2D Static Loading Case Studies, 3D Static Loading Case Studies, Impact Loading, Beam Loading.	
Module – 3	**08 Hrs**
Stress and Strain: Stress, Strain, Principal Stress, Plane Stress and Plane Strain, Mohr's Circle, Applied Versus Principal Stresses, Axial Tension, Direct Shear Stress, Bearing Stress and Tearout.	
Module – 4	**08 Hrs**
Deflection: Beams and Bending Stresses, Deflection in Beams, Torsion, Combined Stresses, Spring Rates, Stress Concentration, Stresses in Cylinders, Case Studies In Static Stress And Deflection Analysis.	
Module – 5	**08 Hrs**
Static Failure Theories: Failure of Ductile Materials, Failure of Brittle Materials, Case Studies: Bicycle Brake Lever, Crimping Tool, Automobile Scissors- jack, Bicycle Brake Arm.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Define basic philosophies used in Machine Design
CO2	Design and Analyze any geometrically well-defined component subjected to static loading

CO3	Design and Analyze a simple component subjected to fatigue loading

Text Books	
1	Robert L. Norton, Machine design - An Integrated Approach, 4th Edition, Prentice- Hall, 2011.
2	R G Budynas, and J K Nisbett, Shigley's Mechanical Engineering Design, 9th Edition, McGraw Hill,2011

Skill Development Activities Suggested	
1	Write a small C Program to design a shaft for both static and dynamic loading
2	Compute the fatigue life of simple rod subject to constant amplitude load in a commercial software.
3	Learn the usage of MSC Fatigue Module of NASTRAN

Web links and Video Lectures (e – Resources)	
1	https://www.machinedesign.com/
2	https://archive.nptel.ac.in/courses/112/105/112105125/
3	https://archive.nptel.ac.in/courses/112/105/112105124/

CO – PO MAPPING

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

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

Semester: II						
MECHANICS OF COMPOSITE MATERIALS						
Course Code	**:**	**MME206**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Comprehend the basics of Composite Materials.
CLO2	Select composite materials.
CLO3	Conduct stress and Stiffness analyses of Lamina and Laminate.
CLO4	Use the theories of failure of composite materials under static loading.

Module – 1	**08 Hrs**
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	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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.	
Module – 4	**08 Hrs**
Ply Strength: Lamina Failure Criteria-Strength Ratio, Maximum Stress Criterion, Maximum Strain Criterion, Interacting Failure Criterion, First Ply Failure, Last Ply Failure, Laminate Strength.	
Module – 5	**08 Hrs**

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.

Course Outcomes: After completing the course, the students will be able to	
CO1	Select Composite Materials based on the need of the situation.
CO2	Design and analyse the lamina in its various orientations.
CO3	Design and Analyse a composite laminate.

Text 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

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

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

CO – PO MAPPING

	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

ABILITY / SKILL ENHANCEMENT COURSES (OFFLINE)

Semester: II						
NUMERICAL PROGRAMMING FOR MECHANICAL ENGINEERS (Using MATLAB/NumPy)						
Course Code	**:**	**MME208A**		**Credits**	**:**	01
Hours/Week(L:T:P)	**:**	0:0:2		**CIE**	**:**	50 Marks
Total Hours	**:**	15		**SEE**	**:**	50 Marks
Course Type	**:**	AEC/SEC		**SEE Duration**	**:**	1 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Note: Instead of MATLAB any equivalent open source and commercial software can be used

Course Learning Objectives: This course will enable the students to	
CLO1	Gain knowledge of basic numerical methods and algorithms used in mechanical engineering.
CLO2	Understand the mathematical foundations and applications of numerical techniques.
CLO3	Learn to use MATLAB and NumPy for numerical problem-solving in mechanical engineering contexts.
CLO4	Familiarize with key concepts in solving linear and nonlinear equations, interpolation, and numerical differentiation.
CLO5	Learn to apply numerical methods for mechanical engineering simulations and error analysis.

Module – 1	**03 Hrs**
Introduction to Numerical Programming **Overview of Numerical Methods:**Basic definitions and examples of numerical methods, Significance of numerical programming in engineering. **Introduction to MATLAB and NumPy:** Syntax, commands, and basic operations, Understanding variables, matrices, and vectors. **Basic Programming Constructs:** Loops, conditional statements, and functions, Debugging techniques in MATLAB/NumPy.	
Module – 2	**03 Hrs**
Solving Linear and Nonlinear Equations: **Linear Systems of Equations:** Gaussian elimination, LU decomposition. **Iterative methods:** Jacobi and Gauss-Seidel. **Nonlinear Equations:** Bisection method, Newton-Raphson method, Fixed-point iteration	
Module – 3	**03 Hrs**
Numerical Differentiation and Integration: **Numerical Differentiation:** Forward and backward difference methods, Central difference approximation. **Numerical Integration:** Trapezoidal rule, Simpson's rule	
Module – 4	**03 Hrs**
Interpolation and Curve Fitting: Polynomial Interpolation: Lagrange and Newton interpolation methods, Application to curve fitting. Least Squares Method: Fitting a linear model to data points	
Module – 5	**03 Hrs**

Numerical Solutions of Ordinary Differential Equations (ODEs)
Introduction to ODEs: Types of ordinary differential equations in mechanical engineering, Initial value and boundary value problems. Numerical Methods for ODEs: **Euler's method, Runge-Kutta methods (4th order)**

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify the appropriate numerical method for a given engineering problem.
CO2	Understand and recognize various methods for solving equations, integration, and interpolation.
CO3	Select suitable algorithms for solving ODEs in mechanical engineering.
CO4	Evaluate the accuracy of numerical methods and identify common sources of error.
CO5	Apply numerical methods to basic mechanical engineering problems using MATLAB/NumPy.

Text Books	
1	"**Numerical Methods for Engineers**" by Steven C. Chapra and Raymond P. Canale
2	"**Applied Numerical Methods with MATLAB for Engineers and Scientists**" by Steven C. Chapra
3	"**Numerical Methods in Engineering with Python 3**" by Jaan Kiusalaas
4	"**MATLAB for Engineers**" by Holly Moore
5	"**Python for Engineers and Scientists**" by E.M. Kranakis

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	Collaborative Learning
2	Gamification of Learning
3	Online Code Repositories

Web links and Video Lectures (e – Resources)	
1	**MATLAB Documentation:** https://www.mathworks.com/help/matlab/
2	**NumPy Documentation:** https://numpy.org/doc/stable/
3	**MIT OpenCourseWare - Numerical Methods:** https://ocw.mit.edu/courses/mechanical-engineering/
4	**Coursera - Numerical Methods for Engineers:**https://www.coursera.org/learn/numerical-methods- engineering
5	**SciPy Documentation (for advanced numerical computing):** https://docs.scipy.org/doc/scipy/

Semester: II						
PYTHON PROGRAMMING FOR BEGINNERS						
Course Code	**:**	**MME208B**		**Credits**	**:**	01
Hours/Week(L:T:P)	**:**	0:0:2		**CIE**	**:**	50 Marks
Total Hours	**:**	15		**SEE**	**:**	50 Marks
Course Type	**:**	AEC/SEC		**SEE Duration**	**:**	1 Hours(MCQ)

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the fundamentals of Python programming, including variables, control structures, and data types.
CLO2	Develop basic Python scripts to solve computational problems.
CLO3	Understand and use functions, libraries, and modules to enhance programming capabilities.
CLO4	Learn to work with files and handle exceptions in Python.
CLO5	Apply Python programming skills to solve practical, real-world problems in mechanical engineering and other domains.

Module – 1	**03 Hrs**
Introduction to Python Programming • **Python Basics:** Variables, data types, and basic operators. • **Control Structures:** If-else conditions, loops (for, while). • **Basic Input/Output:** Reading from and writing to the console.	
Module – 2	**03 Hrs**
Data Structures and Collections • **Lists and Tuples:** Creating and manipulating lists and tuples. • **Dictionaries and Sets:** Using dictionaries for key-value pairs, and sets for unique elements. • **List Comprehensions:** Efficiently creating and modifying lists.	
Module – 3	**03 Hrs**
Functions and Modular Programming • **Functions:** Defining and calling functions, parameters, and return values. • **Lambda Functions:** Anonymous functions for compact code. • **Modules:** Importing and using Python standard libraries.	
Module – 4	**03 Hrs**
File Handling and Exception Handling • **Reading and Writing Files:** Handling text and binary files. • **Exception Handling:** Try-except blocks to manage errors gracefully. • **Context Managers:** Using with statements for file management.	
Module – 5	**03 Hrs**

Introduction to Libraries for Engineering Applications
• **NumPy:** Arrays, mathematical operations, and linear algebra. • **Matplotlib:** Basic plotting and visualization for engineering data. • **Integration with Mechanical Systems:** Simple Python applications to solve engineering problems.

Course Outcomes: After completing the course, the students will be able to	
CO1	Write and execute simple Python programs
CO2	Implement control structures (e.g., loops, conditionals) and data structures (e.g., lists, dictionaries)
CO3	Create and call functions to modularize and reuse code.
CO4	Handle errors and exceptions to ensure program stability.
CO5	Use libraries such as NumPy and Matplotlib for basic engineering calculations and data visualization.

Text Books	
1	"**Automate the Boring Stuff with Python**" by Al Sweigart
2	"**Python Crash Course**" by Eric Matthes
3	"**Learning Python**" by Mark Lutz
4	"**Python for Data Analysis**" by Wes McKinney
5	**“Python Programming: An Introduction to Computer Science**" by John Zelle

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning	
1	**Interactive Online Coding Platforms:** Encourage students to practice coding through interactive platforms like **Replit**, **Jupyter Notebooks**, or **Google Colab** where they can run Python code directly in their browsers.
2	**Project-Based Learning:** Assign small projects where students can apply the concepts learned in the modules. Example projects could include writing a Python script to calculate the area of mechanical components, plotting data from experiments, or solving simple mathematical problems related to mechanical engineering.
3	**Online Tutorials and Video Resources:** Provide links to YouTube channels or online courses that explain the course concepts in depth, such as **Corey Schafer's Python tutorials** or the **Python for Everybody** Coursera series.

Web links and Video Lectures (e – Resources)	
1	**Python Official Documentation:**https://docs.python.org/3/
2	**W3Schools Python Tutorial:** https://www.w3schools.com/python/
3	**Python for Everybody (Coursera):**https://www.coursera.org/specializations/python
4	**NumPy Documentation:** https://numpy.org/doc/stable/
5	**Matplotlib Documentation:** https://matplotlib.org/stable/contents.html

Semester: II						
MECHANICAL SIMULATION LABORATORY						
Course Code	**:**	**MMEL207**		**Credits**	**:**	02
Hours/Week(L:T:P)	**:**	0:0:4		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PCCL		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Apply Finite Element Analysis (FEA) to solve structural problems and understand stress, strain, and deformation in mechanical components.
CLO2	Analyze multi-body dynamic systems using simulation tools to evaluate kinematics and dynamic behaviours of mechanisms.
CLO3	Implement computational optimization techniques to improve the performance and efficiency of mechanical structures.
CLO4	Model and simulate mechanical systems such as gears, trusses, and linkages using industry-standard software.
CLO5	Utilize machine learning techniques for the classification of material properties based on mechanical characteristics.

**** Software mentioned are representative only, any other equivalent commercial or open source software can be used**

Sl No	Name of Experiment
1	**Static Structural Analysis of a Cantilever Beam** • **Objective:** Analyze a **cantilever beam** subjected to a point load. • **Software:** MSC Nastran / MATLAB • **Outcome:** Understanding **stress, displacement, and boundary conditions**.
2	**Modal Analysis of a Plate Structure** • **Objective:** Compute the **natural frequencies and mode shapes** of a rectangular plate. • **Software:** MSC Nastran / Python • **Outcome:** Learning **eigenvalue analysis** for vibration studies.
3	**Multi-Body Dynamic Simulation of a Four-Bar Mechanism** • **Objective:** Simulate a **four-bar linkage** and analyze motion parameters like velocity and acceleration. • **Software:** MSC Adams • **Outcome:** Understanding **kinematic and dynamic behavior of mechanisms**.
4	**Finite Element Analysis of a 2D Truss Structure** • **Objective:** Solve a **2D truss problem** using the **stiffness matrix method**. • **Software:** MATLAB / MSC Nastran • **Outcome:** Understanding **axial forces, stress distribution, and deformations**.
5	**Optimization of Structural Components using Quadratic Programming** • **Objective:** Optimize a mechanical component **subjected to constraints using quadratic programming**. • **Software:** Python (cvxopt) • **Outcome:** Exposure to **optimization techniques in mechanical design**.
6	**Multi-Body Dynamic Analysis of a Suspension System** • **Objective:** Simulate and analyze a **vehicle suspension system** under a road profile.

	• **Software:** MSC Adams • **Outcome:** Understanding **shock absorption, damping, and ride comfort**.
7	**Computational Analysis of a Simple Gear Train** • **Objective:** Model and simulate a **gear train** to evaluate torque transmission and speed ratios. • **Software:** MSC Adams • **Outcome:** Understanding **gear motion, forces, and efficiency**.
8	**Machine Learning-Based Classification of Material Properties** • **Objective:** Apply **K-Means and Fuzzy C-Means clustering** to classify materials based on mechanical properties. • **Software:** Python (scikit-learn, NumPy) • **Outcome:** Understanding **unsupervised learning applications in material classification**.
	Demonstration Experiments (For CIE) if any
9	**Buckling Analysis of a Slender Column** • **Objective:** Simulate buckling behavior of a **column under axial compression**. • **Software:** MSC Nastran • **Outcome:** Understanding **critical load determination and stability analysis**.
10	**Impact Analysis of a Drop Test on a Mechanical Component** • **Objective:** Simulate an impact test for a **falling object striking a rigid surface**. • **Software:** MSC Nastran / MATLAB • **Outcome:** Understanding **stress wave propagation and impact forces**.
11	**Fatigue Analysis of a Rotating Shaft** • **Objective:** Perform a **fatigue life prediction** for a rotating shaft under cyclic loading. • **Software:** MSC Nastran • **Outcome:** Understanding **failure prediction and fatigue cycles**.
12	**Topology Optimization of a Mechanical Bracket** • **Objective:** Optimize the **shape and material distribution** of a mechanical bracket to minimize weight while maintaining strength. • **Software:** MSC Nastran / MATLAB • **Outcome:** Understanding **design optimization and lightweight structures**.

Course Outcomes: After completing the course, the students will be able to	
CO1	**Perform static and dynamic analysis** of mechanical components using FEA-based software like MSC Nastran and MATLAB.
CO2	**Simulate and evaluate motion characteristics** of multi-body systems such as linkages, suspensions, and gear trains using MSC Adams.
CO3	**Solve optimization problems** in mechanical engineering using Python-based quadratic programming techniques.
CO4	**Analyze real-world mechanical problems** and validate results through computational simulations.
CO5	**Apply AI-based clustering techniques** to classify materials based on their mechanical properties using Python.

Text Books	
1	**Zienkiewicz, O.C., & Taylor, R.L.** (2013). The Finite Element Method: Its Basis and Fundamentals (7th ed.). Elsevier.
2	**Chandrupatla, T.R., & Belegundu, A.D.** (2011). Introduction to Finite Elements in Engineering (4th ed.). Pearson.
3	**Madier, D.** (2018). Practical Finite Element Analysis (1st ed.). Independently Published.
4	**Nakasone, Y., Yoshimoto, S., & Stolarski, T.** (2017). Engineering Analysis with ANSYS Software (2nd ed.). Butterworth-Heinemann.
5	**Gattringer, H., & Gerstmayr, J.** (2013). Multibody System Dynamics, Robotics and Control (1st ed.). Springer.
6	**Shabana, A.A.** (2013). Dynamics of Multibody Systems (4th ed.). Cambridge University Press.
7	**Flores, P., & Lankarani, H.M.** (2015). Introduction to Multibody Dynamics: Solutions and Practical Applications (1st ed.). Springer.
8	**Boyd, S., & Vandenberghe, L.** (2004). Convex Optimization (1st ed.). Cambridge University Press.
9	**Bishop, C.M.** (2006). Pattern Recognition and Machine Learning (1st ed.). Springer.
10	**Nagarajan, R.** (2021). Data Science for Engineers (1st ed.). Cambridge University Press.
11	**Meriam, J.L., & Kraige, L.G.** (2016). Engineering Mechanics: Dynamics (8th ed.). Wiley.
12	**Hibbeler, R.C.** (2021). Mechanics of Materials (10th ed.). Pearson.

Web links and Video Lectures (e – Resources)	
1	**MSC Software Learning Hub** – https://www.mscsoftware.com/
2	**Finite Element Analysis Blog** – https://www.simscale.com/blog/
3	**Introduction to FEA** (MIT Open Course Ware) – https://ocw.mit.edu/courses/mechanical-engineering/
4	**MSC Adams Tutorials** – https://www.mscsoftware.com/products/adams
5	**Multibody Dynamics Simulations** – https://www.comsol.com/multibody-dynamics-module
6	**Python Quadratic Programming (cvxopt)** – https://cvxopt.org/

Professional Elective III

Semester: II						
OPTIMIZATION TECHNIQUES						
Course Code	**:**	**MME204A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Enumerate the fundamental knowledge of Linear Programming and Dynamic Programming problems.
CLO2	Learn classical optimization techniques and numerical methods of optimization.
CLO3	Know the basics of different evolutionary algorithms
CLO4	Explain Integer programming techniques and apply different optimization techniques to solve various models arising from engineering areas

Module – 1	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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	
Module – 3	**08 Hrs**
Genetic Algorithm (GA): Differences and similarities between conventional and evolutionary algorithms, working principle, Genetic Operators- reproduction, crossover, mutation.	
Module – 4	**08 Hrs**
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.	
Module – 5	**08 Hrs**
Integer Programming: Graphical Representation, Gomory's Cutting Plane Method, Balas' Algorithm for Zero–One Programming, Branch-and-Bound Method.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Apply the fundamental knowledge of Linear Programming and Dynamic Programming problems.
CO2	Use classical optimization techniques and numerical methods of optimization.
CO3	Enumerate fundamentals of Integer programming technique and apply different techniques to solve various optimization problems arising from engineering areas.

Text Books	
1	Singiresu S. Rao," Engineering Optimization Theory and Practice", 4th Edition, John Wiley, 2009
2	Kalyanmoy Deb,Optimization for Engineering 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)	
1	Optimization Toolbox (https://in.mathworks.com/products/optimization.html)
2	S.N. Sivanandam, S.N. Deepa , Principles of Soft Computing, 2nd Edition ,2011
3	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.

CO – PO MAPPING

	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

Semester: II						
FATIGUE AND FRACTURE MECHANICS						
Course Code	**:**	**MME204B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Introduce basic aspects of Fatigue and Failure
CLO2	Discuss the availability of various fatigue analysis methods that are used by professional.
CLO3	Know the modifications required in case of mean stress and notches
CLO4	To understand various cycle counting methods used in industries and in commercial software.
CLO5	To understand the basic Fracture Mechanics

Module – 1	**08 Hrs**
Fatigue Damage Theories: Fatigue damage mechanism, Cumulative damage models, and Linear damage models, Double linear damage rule by Manson and Halford.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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.	
Module – 4	**08 Hrs**
Cycle Counting Techniques: One-parameter cycle counting methods, Two-parameter cycle counting methods, Four-Point Cycle Counting Method, Reconstruction of a load-time history.	
Module – 5	**08 Hrs**
Introduction to Fracture Mechanics: assumptions of LEFM, brittle vs. ductile fracture, stress intensity factor (SIF) for Mode I, Mode II, and Mode III, crack tip stress fields, Griffith's energy criterion, Irwin's modification for plastic zone, fracture toughness (K_{IC}) and its measurement, crack tip plasticity models (Irwin and Dugdale), R-curve and stable crack growth, failure prediction, applications in aerospace, automotive, and structural components.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Correctly predict Fatigue life of metal components using Stress and Strain life Methods
CO2	Analyze the situation to apply appropriate fatigue failure method
CO3	Identify and describe the basic fatigue mechanisms.
CO4	Use appropriate Rain counting Method for variable amplitude loading

Text 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)
7	Broek, D. Elementary Engineering Fracture Mechanics, Springer, 1982.

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/)
5	NPTEL Fracture Mechanics Course: https://nptel.ac.in/courses/105/106/105106052/
6	MIT Open Course Ware - Fracture Mechanics: https://ocw.mit.edu/courses/mechanical-engineering/

Skill Development Activities Suggested	
1	Write MATLAB/ SCILAB programs to implement the rain flow counting
2	Run a MSC NASTRAN Fatigue Analysis
3	Try A sample Problem of Spot Welding in MSC Fatigue
4	Explore various Fatigue and Fracture software such as NASGRO, FRANC3D, NISA Endure etc.

CO – PO MAPPING

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

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

Semester: II						
SUSTAINABILITY ENGINEERING						
Course Code	**:**	**MME204C**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To have an increased awareness among students on issues in areas of sustainability
CLO2	To understand the role of engineering and technology with sustainable development.
CLO3	To know the methods, tools and incentives for sustainable products service system development.
CLO4	To establish clear understanding of the role and impact t of various aspects of engineering decisions on environmental, societal and economic problems.

Module – 1	**08 Hrs**
Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
Environmental Management Standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA).	
Module – 4	**08 Hrs**
Resources and its Utilization: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels.	
Module – 5	**08 Hrs**
Sustainability Practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanization, Sustainable cities, Sustainable transport.	

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

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.

Text 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)	
1	VTU e-Shikshana Program
2	VTU EDUSAT Program

Skill Development Activities Suggested	
1	Case study
2	Quizzes
3	Assignments
4	Seminars

CO – PO MAPPING

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

Semester: II						
SIGNAL ANALYSIS AND CONDITION MONITORING						
Course Code	**:**	**MME204D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To study and understand signal and its types.
CLO2	To understand the techniques involved in signal conditioning.
CLO3	To know the different used in structural health monitoring.

Module – 1	**08 Hrs**
Introduction: Basic concepts. Fourier analysis. Bandwidth. Signal types. Convolution.	
Module – 2	**08 Hrs**
Signal analysis: Filter response time. Detectors. Recorders. Analog analyzer types.	
Module – 3	**08 Hrs**
Practical analysis of stationary signals: Stepped filter analysis. Swept filter analysis. High speed analysis. Real-time analysis.	
Module – 4	**08 Hrs**
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.	
Module – 5	**08 Hrs**
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).	

Course Outcomes: After completing the course, the students will be able to	
CO1	Discuss Different Types of Signals Generated
CO2	Apply the various Techniques for Signal Conditioning
CO3	Apply the various Condition Monitoring Techniques

Text 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.

CO – PO MAPPING

	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

Semester: II						
DIGITAL MANUFACTURING						
Course Code	**:**	**MME204E**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understand the Evolution of Industrial Production.
CLO2	Comprehend Digital Manufacturing Systems.
CLO3	Develop Proficiency in CAD and CAM Tools.
CLO4	Explore Additive Manufacturing Technologies.
CLO5	Apply Software and Standards for 3D Printing.

Module – 1	**08 Hrs**
Introduction to Digital Manufacturing: Definition of digital manufacturing, Historical perspective on industrial production and outlook, Industrial Revolutions, Industry 4.0, Cyber-physicalsystem,Factoryofthefuture,OperationModeandArchitectureofDigitalManufacturing System.	
Module – 2	**08 Hrs**
CadModeling: Design process and role of CAD, Types and applications of design models, Three dimensional modelling schemes, Wire frames and surface representation schemes, Solid modelling - Parametric modelling, Assembly modelling.	
Module – 3	**08 Hrs**
Reverse Engineering: Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development. **Computer Aided Manufacturing:** Component modelling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing.	
Module – 4	**08 Hrs**
Additive Manufacturing for Digital Transformation: Introduction to additive manufacturing, Additive manufacturing process chain, Material selection, Manufacturing, Post processing, Additive manufacturing technologies and processes, Vat photo polymerization, Material extrusion, Material jetting, Sheet lamination, Powder bed fusion, Binder jetting, Planning and slicing additive manufacturing software	
Module – 5	**08 Hrs**
Concept Modelers, Translators and 3D Printing Software: Introduction, Principle, Thermo jet printer, Sander's model market, 3- D printer, Genisys Xs printer, JP system 5, object quadra System-Rapid proto typing. Standard interface to convey geometric description from CAD package to Rapid prototyping system, Stereo Lithography (STL)file, Initial Graphics Exchange Specification(IGES)file, Hewlett-Packard Graphics Language(HP/GL) file. **Additive manufacturing software for editing features and to export files to printers**: Ansys, Autodesk Netfabb, 3dSystems, Materialise Magics, Solid Edge, Amphyon.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain Architecture of Digital Manufacturing System.
CO2	Discuss on the Role of CAD and Design Process in Digital Manufacturing.
CO3	Explain the Application of Reverse Engineering in Digital Manufacturing/Discuss on the Principles and Processes of Additive Manufacturing
CO4	Explain the principal and process involved in development of parts by additive manufacturing.
CO5	Discuss on the use of digital manufacturing equipment/explain the role of software in digital manufacturing

Text Books	
1	Zude ZhouShane (Shengquan) Xie Dejun Chen,"Fundamentals of Digital Manufacturing Science"Springer Series in Advanced Manufacturing,2012 (Unit-I)
2	Ibrahim Zeid and Sivasubramanian R, "CAD/CAM - Theory and Practice", Tata McGraw Hill Education, 2011. (Unit-II)
3	VineshRajaandKiranJFernandes,"ReverseEngineering-AnIndustrialPerspective", Springer-Verlag, 2008(Unit-III)
4	Chua C.K., Leong K.F. and Lim C.S., Rapid Prototyping: Principles and Applications, 3rd Edition, World scientific publications, 2014.(Unit-IV&V).
5	Pham D T and Dimov S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping", Springer-Verlag, 2001.
6	Gerard JounghyunKim,"DesigningVirtualSystems:TheStructuredApproach", Springer, 2005.
7	AnttiSaaksvuoriandAnselmiImmonen,"ProductLifecycleManagement",Springer, 2004.

Web links and Video Lectures (e – Resources)	
1	NPTEL. (2022). Digital Manufacturing and Industry 4.0. National Programme on Technology Enhanced Learning (NPTEL), IIT Madras. https://nptel.ac.in/courses/106/106/106106216/
2	Autodesk. (2024). Autodesk Learning Hub – Fusion 360 & AutoCAD. https://www.autodesk.com/learning
3	MIT Open Course Ware. (2019). Additive Manufacturing – Design and Manufacturing II. Massachusetts Institute of Technology https://ocw.mit.edu/courses/mechanical-engineering/2-008-design-and-manufacturing-ii- spring-2019/
4	3D Systems. (2024). Learning Center for 3D Printing and Rapid Prototyping https://www.3dsystems.com/learning-center

Skill Development Activities Suggested	
1	Explore virtual simulations of Industry 4.0 environments
2	Design 3D CAD models using SolidWorks, AutoCAD, or Fusion 360 or any equivalent software.
3	Perform parametric and assembly modeling of components.
4	Practice 3D scanning and geometric reconstruction.
5	Develop CAD models from scanned point cloud data
6	Generate CNC tool paths using CAM software.
7	Simulate machining and perform post-processing.
8	Edit and optimize 3D models using Netfabb or Magics.

CO – PO MAPPING

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

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

Professional Elective IV

Semester: II						
MECHANICAL BEHAVIOUR OF MATERIALS						
Course Code	**:**	**MME205A**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To familiarize the concept of deformation mechanisms in single crystal and polycrystalline materials.
CLO2	To study strengthening mechanisms and mechanics of fracture in ductile and brittle materials.
CLO3	To study the fatigue and creep properties of materials under various conditions.
CLO4	To familiarize the various characterization techniques used to probe mechanical properties.

Module – 1	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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 strain hardening, Annealing of cold worked metal.	
Module – 4	**08 Hrs**
Creep and Stress Rupture: Creep curve, Stress rupture test, Mechanism of creep deformation, Activation energy for steady state creep, Super plasticity, Fracture at elevated temperature, Creep resistant alloys, Creep under combined stresses.	
Module – 5	**08 Hrs**
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.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the effect of dislocations and their interaction on the material strength.
CO2	Apply the concept of fracture toughness to material failure.
CO3	Carry out the Tensile test for a steel specimen.

Text 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.

Web links and Video Lectures (e – Resources)	
1	Mechanical Behavior of Materials https://onlinecourses.nptel.ac.in/noc21_mm27/preview
2	Mechanical Behavior 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.

CO – PO MAPPING

	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

Semester: II						
BASICS OF MACHINE LEARNING						
Course Code	**:**	**MME205B**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To understand the basic theory underlying machine learning.
CLO2	To be able to formulate machine learning problems corresponding to different applications.
CLO3	To understand a range of machine learning algorithms along with their strengths and weaknesses.
CLO4	To be able to apply machine learning algorithms to solve problems of moderate complexity.
CLO5	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	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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, **Nearest neighbour methods** - Nearest Neighbour Smoothing, Efficient Distance Computations: the KD-Tree, Distance Measures.	
Module – 4	**08 Hrs**
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	
Module – 5	**08 Hrs**
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.	
Course Outcomes: After completing the course, the students will be able to	
CO1	Choose the learning techniques with this basic knowledge
CO2	Apply effectively genetic algorithms for appropriate applications.
CO3	Apply Bayesian techniques and derive effectively learning rules.
CO4	Choose and differentiate Clustering & Unsupervised Learning and Language Learning

Text Books	
1	Tom M. Mitchell , "Machine learning", McGraw Hill 1997
2	M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3	Rajjan Shinghal, "Pattern Recognition", Oxford Press, 2006.
4	Ethem Alpaydin, "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-Inter science, 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)	
1	VTU e-Shikshana Program
2	VTU EDUSAT Program

Skill Development Activities Suggested	
1	Mini project on live working model/ Problems.
2	Seminar
3	Assignment

CO – PO MAPPING

	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

Semester: II						
DESIGN FOR MANUFACTURING AND ASSEMBLY						
Course Code	**:**	**MME205C**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**YES**
Knowledge on Fundamental Concepts	**YES**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Understanding the basic rules for design for manufacturing and material selection.
CLO2	Applying the guidelines for ease of design, manufacturing and assembly.
CLO3	Analyze factors for selection of material and process, relationship to manufacturing processes.
CLO4	Apply the concepts of design for manufacturing and assembly for product manufacturing.
CLO5	Compare various manufacturing processes and assembly techniques required for product development to optimize the process.

Module – 1	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
Component design – Casting Considerations – Pattern, Mould, parting line, cast holes, machined holes, identifying parting line, special sand cores, designing to obviate sand cores. Examples	
Module – 4	**08 Hrs**
Design for Injection: Molding 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.	
Module – 5	**08 Hrs**
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.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the principles of manufacturability and design for manufacture.
CO2	Design casting for economic production.
CO3	Understand the concept of easy assembly, based on rules of DFMA to reduce the time of assembly.
CO4	Redesign the parts for easy manufacturing based on rules of DFMA to reduce the time of manufacturing and enhance cost effectiveness.
CO5	Design guidelines and background for powder metallurgy parts and reviewing of formed parts.

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

Web links and Video Lectures (e – Resources)	
1	VTU e-Shikshana Program
2	VTU EDUSAT Program

Skill Development Activities Suggested	
1	Quizzes.
2	Seminar
3	Assignment

CO – PO MAPPING

	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

Semester: II						
DESIGN OF AEROSPACE STRUCTURES						
Course Code	**:**	**MME205D**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	To study basic concepts of aircraft structures & materials, and various types of loads acting on an aircraft.
CLO2	To understand concepts of open and closed thin walled beams.
CLO3	To acquire the knowledge of buckling of plates, joints and fittings.
CLO4	Comprehend the stress analysis on wings and fuselage.

Module – 1	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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.	
Module – 4	**08 Hrs**
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.	
Module – 5	**08 Hrs**
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.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the various loads acting on aircraft.
CO2	Understand various types of materials used in aircraft configuration
CO3	Apply the concept of thin walled beams.
CO4	Calculate the buckling of plates.
CO5	Analyze the stresses in wings and fuselage structures/frames

Text 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.

CO – PO MAPPING

	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

Semester: II						
INTRODUCTION TO HYBRID AND ELECTRIC VEHICLES						
Course Code	**:**	**MME205E**		**Credits**	**:**	03
Hours/Week(L:T:P)	**:**	3:0:0		**CIE**	**:**	50 Marks
Total Hours	**:**	40		**SEE**	**:**	50 Marks
Course Type	**:**	PEC		**SEE Duration**	**:**	3 Hours

Prerequisites:	
Courses	**NIL**
Knowledge on Fundamental Concepts	**NIL**
Knowledge on Connected Tools (If any)	**NIL**

Course Learning Objectives: This course will enable the students to	
CLO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
CLO2	Analyze various electric drives suitable for hybrid electric vehicles.
CLO3	Discuss different energy storage technologies used for hybrid electric vehicles and their control.
CLO4	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	**08 Hrs**
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.	
Module – 2	**08 Hrs**
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.	
Module – 3	**08 Hrs**
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.	
Module – 4	**08 Hrs**
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.

Module – 5	**08 Hrs**
Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
CO2	Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology
CO3	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.

Text 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)

Skill Development Activities Suggested	
1	Simulate the electric vehicle in MATLAB/SCILAB modules

CO – PO MAPPING

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

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

Institute Vision

Preparing Competent Engineering and Management Professionals to Serve the Society

Institute Mission

- **Providing Students with a Sound Knowledge in Fundamentals of their branch of Study.**
- **Promoting Excellence in Teaching, Training, Research and Consultancy.**
- **Exposing Students to Emerging Frontiers in various domains enabling Continuous Learning.**
- **Developing Entrepreneurial acumen to venture into Innovative areas.**
- **Imparting Value based Professional Education with a sense of Social Responsibility.**

Department Vision

Building Technically Competent Engineers to Serve the Society

Department Mission

- **Imparting strong fundamental knowledge in Mechanical Engineering and allied fields.**
- **Fostering a culture of collaboration and propagating Industry institute interactions to enhance advances in latest technologies.**
- **Creating State-of-Art facilities benefitting students and faculty to carryout Research, Innovation and Consultancy.**
- **Providing conducive environment for both students and faculty to engage in lifelong learning activities.**
- **Inculcating Professional ethics, Leadership qualities and Entrepreneurial skills among students.**

SJC INSTITUTE OF TECHNOLOGY

An Autonomous Institution under VTU from 2024-25

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