17MEX39 - 3D PRINTING TECHNOLOGY				
L	T	P	C	
3	0	0	3	
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the concept of open source 3D printers and rapid tooling	1.1	The students will be able to apply 3D printing tools for component design	a,b,c,e,l
2.0	To learn the contemporary technology available for 3D printing	2.1	The students will be able to choose the contemporary technology available for 3D design and printing	a,b,c,e,l
3.0	To understand the 3D printer design criteria	3.1	The students will be able to design their own 3D printer based on application.	a,b,c,d
4.0	To make the students to Understand various post processing methods involved in 3D printing technology	4.1	The students will be able to Apply various post processing methods involved in 3D printing technology	b,c,e,l
5.0	To gain knowledge about the materials used in 3D printing	5.1	The students will be able to find the utility of various materials in 3D printing applications	a,b,c,e,l

UNIT I - 3D DESIGN TOOLS	(9)
Object creation workflow, Constructing object primitives to scale and with accuracy - Duplication and arrayed duplication - Grid and point/vertex snapping - Understanding 3D geometry - Modeling workflows for Polygons - Additive vs Subtractive Tools - Mesh editing - Best Practices for constructing printable polygon meshes - Fundamental Structure - Combining, merging, and sewing up polygon meshes - Problems with the STL File Format	
UNIT II -DESIGN AND CALIBRATION OF A 3D PRINTER	**(9)**
Necessary Parts of 3D Printer - Functional Description and Design Analysis - Build Process - Future Improvements - Types of 3D Printing Software - Printer Software Configuration - Testing the 3D Printer Movement - The First Print - Creating or Downloading a Part - Configuring the Software - Final Print Configuration - Accuracy - Fill - Skirt - Speed and Temperature - Support Structure - Filament - Printing	
UNIT III - POST PROCESSING - PRODUCT VISUALIZATION AND PRINT CLEANING	**(9)**
Workflows for printing - Software and Drivers - Formats for Printing - Post and Export Print Lab setup - Cleanup and airtight modeling - Loading models and arranging print stage - Printing - Removing support material.	

UNIT IV - MATERIALS FOR 3D PRINTING.	(9)
Types of Materials - Polymers - Thermoplastic Polymers, Thermosetting Polymers and Elastomers - Metals - Ceramics - Composites - Liquid-Based Materials - Solid-Based Materials - Powder-Based Materials - Common Materials Used in 3D Printers - PLA, ABS, PC and Polymides - Materials Selection Considerations	
UNIT V -APPLICATIONS OF 3D PRINTING AND DESIGN FOR ADDITIVE MANUFACTURING	(9)
Medical and dental applications of 3D Printing - Bioprinting tissues and organs - dental implants - prosthetics - orthotics - introduction to design for additive manufacturing - seven rules of design of additive manufacturing - tutorial with laboratory demonstration	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. RafiqNoorani, "3D Printing Technology, Applications and Selection", CRC Press, 2018
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010

REFERENCES:

1. Hod Lipson, Melba Kurman, Fabricated: The New World of 3D Printing, Wiley, 2013
2. 3D Anatomy Models: http://lifesciencedb.jp/bp3d/?lng=en
3. AutoDesk Fusion360 HomePage: http://fusion360.autodesk.com
4. International Journal of Rapid Manufacturing
5. Matthew Griffin, Design and Modeling for 3D Printing, Maker Media, Inc., 2013.
6. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003
7. Ali K. Kamrani, EmandAbouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
8. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

17MEX42 DIGITAL MANUFACTURING AND IoT			
L	T	P	C
3	0	0	3

PREREQUISITE : NIL

COURSE OBJECTIVES AND OUTCOMES:

	Course Objectives		Course Outcomes	Related Program outcomes
1.0	To study the various aspects of digital manufacturing.	1.1	Impart knowledge to use various elements in the digital manufacturing.	a,c,d,e,f,h,l,j
2.0	To inculcate the importance of DM in Product Lifecycle Management and Supply chain Management.	2.1	Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.	a,c,d,e,f,h,l,j
3.0	To formulate of smart manufacturing systems in the digital work environment.	3.1	Select the proper procedure of validating practical work through digital validation in Factories.	a,c,d,e,f,h,l,j
4.0	To interpret IoT to support the digital manufacturing.	4.1	Implementation the concepts of IoT and its role in digital manufacturing.	a,c,d,e,f,h,l,j
5.0	To elaborate the significance of digital twin.	5.1	Analyse and optimize various practical manufacturing process through digital twin.	a,c,d,e,f,h,l,j

UNIT I - INTRODUCTION TO DIGITAL MANUFACTURING AND IoT	(9)
Introduction - Need - Overview of Digital Manufacturing and the Past - Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management - Practical Benefits of Digital Manufacturing - The Future of Digital Manufacturing.	
UNIT II - DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT	**(9)**
Collaborative Product Development, Mapping Requirements to specifications - Part Numbering, Engineering Vaulting, and Product reuse - Engineering Change Management, Bill of Material and Process Consistency - Digital Mock up and Prototype development - Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM	
UNIT III - SMART FACTORY	**(9)**
Smart Factory - Levels of Smart Factories - Benefits - Technologies used in Smart Factory - Smart Factory in IoT- Key Principles of a Smart Factory - Creating a Smart Factory - Smart Factories and Cybersecurity	
UNIT IV - INDUSTRY 4.0	**(9)**
Introduction - Industry 4.0 -Internet of Things - Industrial Internet of Things - Framework: Connectivity devices and services - Intelligent networks of manufacturing - Cloud computing - Data analytics - Cyber physical systems -Machine to Machine communication - Case Studies.	
UNIT V - STUDY OF DIGITAL TWIN	**(9)**
Basic Concepts - Features and Implementation - Digital Twin: Digital Thread and Digital Shadow- Building Blocks - Types - Characteristics of a Good Digital Twin Platform - Benefits, Impact & Challenges - Future of Digital Twins.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:
1. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012. 2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.
REFERENCES:
1. Lihui Wang and Andrew YehChing Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009. 2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019. 3. Alp Ustundag and EmreCevikcan, “Industry 4.0: Managing The Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2017 4. Ronald R. Yager and Jordan PascualEspada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018. 5. Ronald R. Yager and Jordan PascualEspada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018.

17MEX43 LEAN MANUFACTURING					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the basics of 6 SIGMA	1.1	Discuss the basics of 6 SIGMA	a,b,c,d,e,l,k,l
2.0	To learning about the lean manufacturing tools.	2.1	Elaborate the lean manufacturing tools.	a,b,c,d,e,l,k,l
3.0	To study about the deeper understanding methodologies of Lean manufacturing.	3.1	Illustrate about the deeper understanding methodologies of Lean manufacturing.	a,b,c,d,e,l,k,l
4.0	To study the lean concepts and its elements.	4.1	Discuss lean concepts and its elements.	a,b,c,d,e,l,k,l
5.0	To learn implementation and challenges of lean manufacturing.	5.1	Describe the implementation and challenges of lean manufacturing.	a,b,c,d,e,l,k,l

UNIT I - BASICS OF 6 SIGMA	(9)
Introduction to 6 Sigma, basic tools of six sigma like problem solving approach, standard deviation, normal distribution, various sigma levels with some examples, value for the enterprise, Variation, and sources of variation, Mean and moving the mean, Various quality costs, cost of poor quality.	
UNIT II - INTRODUCTION TO LEAN MANUFACTURING TOOLS	(9)
Process Capability Indices, Cause and Effect diagram, Control Charts, Introduction to FMEA, APQP, PPAP. 3 foundational 6 Sigma methodologies: DMAIC, DMEDI, and Process Management DMEDI for process creation, DMAIC for process improvement and PDCA for sustaining improvements.	
UNIT III - DEEPER UNDERSTADING METHODOLOGIES	(9)
What is a process, Why Process management, Keys to process management, Difference between process management and 6 Sigma, Introduction to Deming cycle, PDCA, DMAIC and continuous improvement, DMEDI for creation process, DMAIC Vs DMEDI with examples, Introduction to Toyota Production System, Six Sigma and Production System integration.	
UNIT IV - LEAN ELEMENTS	(9)
Introduction to Lean Concepts like In-Built Quality, Concept of Right Part at the Right Time, Lead Time reduction, Optimum utilization of Capital, Optimum utilization of People. Understanding the Zero-defect concept and Metrics, Focus on Human Resources, Quality, Delivery, Cost. Building Zero defect capabilities, Cultural and Organizational aspects	
UNIT V - IMPLEMENTATION AND CHALLENGES	(9)
Implementing Checks and Balances in the process, Robust Information Systems, Dashboard, follow up and robust corrective and preventive mechanism. Concept of Audits, and continuous improvement from gap analysis, risk assessments etc.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:
1. Quality Planning and Analysis- JM Juran& FM Gryna. Tata McGraw Hill 2. Lean Manufacturing: Principles to Practice by Akhilesh N. Singh, Bibliophile SouthAsia 3. The Toyota Way: 14 Management Principles 4. Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy,Masaki Imai
REFERENCES:
1. Quality Council of India https://qcin.org/ & its library. https://qcin.org/nbqp/knowledge_bank/ 2. International Society of Six Sigma Professionals: https://isssp.org/about-us/ 3. NPTEL / SWAYAM: https://nptel.ac.in/courses/110105123 : Six Sigma, Prof. Jitesh J Thakkar, IIT Kharagpur, Certification course. (Self- Learning). 4. Older / Previous editions of AIAG manuals on APQP, FMEA and PPAP. These are great sources of information on Quality Planning and has basics of Project Management and required skills. 5. Quality Management for Organizations Using Lean Six Sigma Techniques- Erick C Jones

17MEX44 MODERN ROBOTICS					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce definition, history of robotics and robot anatomy.	1.0	Discuss the definition, history of robotics and robot anatomy.	a,b,c,d,e,l
2.0	To learn the simulation of robot kinematics	2.0	Develop the simulation of robot kinematics	a,b,c,d,e,l
3.0	To study the grasping and manipulation of robots.	3.0	Describe the grasping and manipulation of robots.	a,b,c,d,e,l
4.0	To study about mobile robot and manipulation.	4.0	Explain about mobile robot and manipulation.	a,b,c,d,e,l
5.0	To study the applications of industrial, service, domestic robots.	5.0	Discuss the applications of industrial, service, domestic robots.	a,b,c,d,e,l

UNIT I - INTRODUCTION	(9)
Robot: Definition, History of Robotics, Robot Anatomy, Co-ordinate systems, types and classification, Configuration space and degrees of freedom of rigid bodies and robots, Configuration space topology and representation; configuration and velocity constraints; task space and workspace, Rigid-body motions, rotation matrices, angular velocities, and exponential coordinates of rotation, Homogeneous transformation matrices.	
UNIT II - SIMULATION OF ROBOT KINEMATICS	(9)
Robot kinematics, Forward and inverse kinematics (two three four degrees of freedom), Forward and inverse kinematics of velocity, Homogeneous transformation matrices, translation and rotation matrices Dennavit and Hartenberg (D-H) transformation, Dynamics of Open Chains, Trajectory Generation, motion planning, robot control: First- and second-order linear error dynamics, stability of a feedback control system.	
UNIT III - GRASPING AND MANIPULATION OF ROBOTS	(9)
Kinematics of contact, contact types (rolling, sliding, and breaking), graphical methods for representing kinematic constraints in the plane, and form-closure grasping, Coulomb friction, friction cones, graphical methods for representing forces and torques in the plane, End effectors, grippers, types of gripper, gripper force analysis, and examples of manipulation and grasping.	
UNIT IV - MOBILE ROBOTS	(9)
Mobile robot, Wheeled Mobile Robots: Kinematic models of omnidirectional and non-holonomic wheeled mobile robots, Controllability, motion planning, feedback control of non-holonomic wheeled mobile robots; odometry for wheeled mobile robots; and mobile manipulation. Reference Trajectory generation, feed forward control	

UNIT V - APPLICATIONS OF ROBOTS	(9)
Application of robotic: industrial robots, Service robots, domestic and house hold robots, Medical robots, military robots, agricultural robots, space robots, Aerial robotics Role of robots in inspection, assembly, material handling, underwater, space and healthcare.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Modern Robotics: Mechanics, Planning, and Control, by Kevin M. Lynch , Frank C. Park , Cambridge University Press; 1st edition (25 May 2017), ISBN-10 : 110715
2. Modern Robotics: Mechanics, Systems and Control, by Julian Evans, Larsen and Keller Education (27 June 2019), ISBN-10 : 1641720751

REFERENCES:

1. Modern Robotics: Designs, Systems and Control, by Jared Kroff, Willford Press (18 June 2019)ISBN-10 : 1682856763
2. Advanced Technologies in Modern Robotic Applications, by ChenguangYang, Hongbin Ma, Mengyin Fu, Springer; Softcover reprint of the original 1st ed. 2016 edition (30 May 2018), ISBN - 10 : 981109263X
3. Modern Robotics: Building Versatile Machines, by Harry Henderson, Facts On File Inc; Illustrated edition (1 August 2006), ISBN-10 : 0816057451
4. Artificial Intelligence for Robotics, by Francis X. Govers, Packt Publishing Limited; Standard Edition (30 August 2018), ISBN-10 : 1788835441
5. Modern Robotics Hardcover by Lauren Barrett (Editor), Murphy & Moore Publishing (1 March 2022), ISBN-10 : 1639873732

17MEX45 GREEN MANUFACTURING DESIGN AND PRACTICES					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the concept of environmental design and industrial ecology.	1.0	Explain the environmental design and selection of eco-friendly materials.	a,b,c,d,g,l,l
2.0	To impart knowledge about air pollution and its effects on the environment.	2.0	Analyse manufacturing processes towards minimization or prevention of air pollution.	a,b,c,d,g,l,l
3.0	To enlighten the students with knowledge about noise and its effects on the environment.	3.0	Analyse manufacturing processes towards minimization or prevention of noise pollution.	a,b,c,d,g,l,l
4.0	To enlighten the students with knowledge about water pollution and its effects on the environment.	4.0	Analyse manufacturing processes towards minimization or prevention of water pollution.	a,b,c,d,g,l,l
5.0	To introduce the concept of green co-rating and its need	5.0	Evaluate green co-rating and its benefits.	a,b,c,d,g,l,l

UNIT I - DESIGN FOR ENVIRONMENT AND LIFE CYCLE ASSESSMENT	(9)
Environmental effects of design -selection of natural friendly material - Eco design - Environmental damage Material flow and cycles - Material recycling - Emission less manufacturing- Industrial Ecology - Pollution prevention - Reduction of toxic emission - design for recycle.	
UNIT II - AIR POLLUTION SAMPLING AND MEASUREMENT	(9)
Primary and Secondary Pollutants, Automobile Pollutants, Industrial Pollution, Ambient air quality Standards, Metrological aspects of air Pollution, Temperature lapse Rates and Stability-wind velocity and turbulence-Pump behavior dispersion of air Pollutants-solution to the atmosphere dispersion equation-the Gaussian Plume Model, Air pollution sampling-collection of gaseous air pollutants-collection of particulate pollutants-stock sampling, analysis of air pollutants-sulfur dioxide-nitrogen dioxide, carbon monoxide, oxidants and ozone.	
UNIT III - NOISE POLLUTION AND CONTROL	(9)
Frequency and Sound Levels, Units of Noise based power radio, contours of Loudness. Effect of human, Environment and properties, Natural and Anthrogenic Noise Sources, Measuring Instruments for frequency and Noise levels, Masking of sound, Types, Kinetics, Selection of different reactors used for waste treatment, Treatment of noise at source, Path and Reception, Sources of noise, Effects of noise- Occupational Health hazards, thermal Comforts, Heat Island Effects, Radiation Effects.	
UNIT IV - WATER DEMAND AND WATER QUALITY	(9)
Factors affecting consumption, Variation, Contaminants in water, Nitrates, Fluorides, Detergents, taste and odour, Radio activity in water, Criteria, for different impurities in water for portable and non-portable use, Point and non-point Source of pollution, Major pollutants of Water, Water Quality Requirement for different uses, Global water crisis issues.	

UNIT V - GREEN CO-RATING	(9)
Ecological Footprint - Need For Green Co-Rating - Green Co-Rating System - Intent - System Approach - Weightage- Assessment Process - Types Of Rating - Green Co-Benefits - Case Studies Of Green Co- Rating	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
2. Rao M.N. and Dutta A.K. "Wastewater treatment", Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2006

REFERENCES:

1. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
2. Frances Cairncross- Costing the Earth: The Challenge for Governments, the Opportunities for Business – Harvard Business School Press – 1993.
3. World Commission on Environment and Development (WCED), Our Common Future, Oxford University Press 2005.
4. Rao M.N. and Dutta A.K. "Wastewater treatment", Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, Second Edition, 2006
5. Rao CS Environmental Pollution Control Engineering-, Wiley Eastern Ltd., New Delhi, 2006.
6. Lewis H Bell and Douglas H Bell, Industrial noise control, Fundamentals and applications, Marcel Decker, 1994.

17MEX46 ENVIRONMENT SUSTAINABILITY AND IMPACT ASSESSMENT					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					
COURSE OBJECTIVES AND OUTCOMES:					
Course Objectives		Course Outcomes		Related Program outcomes	
1.0	To make the students to understand the concepts of Environmental Sustainability & Impact Assessment	1.0	Explain the concepts of Environment Sustainability and trained to make decision related to Environment.	a,c,g,l,l	
2.0	To familiarize the students in environmental decision making procedure.	2.0	Make decision that has an effect on our environment	a,c,g,l,l	
3.0	Make the students to identify, predict and evaluate the economic, environmental, and social impact of development activities	3.0	Evaluate the basics of environmental policy, planning and various legislation Get valuable information for exploring decisions in each life stage of materials, buildings, services and infrastructure.	a,c,g,l,l	
4.0	To provide information on the environmental consequences for decision making	4.0	Explain the Life cycle assessment of Environmental sustainability.	a,c,g,l,l	
5.0	To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.	5.0	Explain sustainable urban economic development.	a,c,g,l,l	

UNIT I – ENVIRONMENTAL IMPACT ASSESMENT	(9)
Environmental impact assessment objectives - rationale and historical development of EIA - Conceptual frameworks for EIA Legislative development - European community directive - Hungarian directive.	
UNIT II - ENVIRONMENTAL DECISION MAKING	(9)
Strategic environmental assessment and sustainability appraisal - Mitigation, monitoring and management of environmental impacts- Socio economic impact assessment.	
UNIT III - ENVIRONMENTAL POLICY, PLANNING AND LEGISLATION	(9)
Regional spatial planning and policy - Cumulative effects assessment - Planning for climate change, uncertainty and risk.	

UNIT IV - LIFE CYCLE ASSESSMENT	(9)
Life cycle assessment; Triple bottom line approach; Industrial Ecology. Ecological foot printing, Design for Environment, Future role of LCA, Product stewardship, design, durability and justifiability, measurement techniques and reporting	
UNIT V - SUSTAINABLE URBAN ECONOMIC DEVELOPMENT	**(9)**
Spatial economics - Knowledge economy and urban regions.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. The Application of Science in Environmental Impact Assessment, by Aaron J. MacKinnon, Peter N. Duinker , Tony R. Walker , Routledge; 1st edition (14 May 2019), ISBN-10 : 0367340194
2. Routledge Handbook of Environmental Impact Assessment, by Kevin Hanna, Routledge; 1st edition (11 April 2022), ISBN-10 : 0367244470

REFERENCES:

1. Clive George, C. Collin, H. Kirkpolarice - Impact Assessment and sustainable development - Edward Elgar Publishing, 2007
2. Robort B Gibsan, Sustainability Assessment, Earth Scan publishers, 2005
3. Simon Dresner, The principle of sustainability - Earth Scan publishers, 2008
4. Canter, R.L., “Environmental Impact Assessment”, McGraw Hill Inc., New Delhi, 1996.
5. Shukla, S.K. And Srivastava, P.R., “Concepts In Environmental Impact Analysis”, Common Wealth Publishers, New Delhi, 1992.
6. John G. Rau And David C Hooten “Environmental Impact Analysis Handbook”, McGraw Hill Book Company, 1990.

17MEX47 ENERGY SAVING MACHINERY AND COMPONENTS				
L	T	P	C	
3	0	0	3	
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the various energy saving machineries and components to the students for the purpose of conserving energy.	1.0	Explain the various energy saving machinery and components.	a,b,c,d,g,l,l
2.0	To study the basics and principles of transforms, Pumps and motors.	2.0	Evaluate the various methods of conservation of energy.	a,b,c,d,g,l,l
3.0	To impart the knowledge about the methods of energy conservation.	3.0	Evaluate the performance and energy conservation of fans, pumps and compressors.	a,b,c,d,g,l,l
4.0	To introduce the energy efficiency devices and concepts of ENCON.	4.0	Discuss the various energy efficiency devices.	a,b,c,d,g,l,l
5.0	To impart the knowledge about CO2 mitigation.	5.0	Explain the co2 mitigation and cost factor.	a,b,c,d,g,l,l

UNIT I - BASICS OF ELECTRICAL ENERGY USAGE	(9)
Fuel to Power : Cascade Efficiency - Electricity Billing : Components and Costs - kVA - Need and Control - Determination of kVA demand and Consumption - Time of Day Tariff - Power Factor Basics - Penalty Concept for PF - PF Correction - Demand Side Management (a brief) - energy monitoring, measurement and analysis.	
UNIT II - TRANSFORMERS AND MOTORS	(9)
Transformer - Basics and Types - AVR and OLTC Concepts - Selection of Transformers - Performance Prediction - Energy Efficient Transformers - Motors : Specification and Selection - Efficiency / Load Curve - Load Estimation - Assessment of Motor Efficiency under operating conditions - Factors affecting performance - ill effects of Rewinding and Over sizing - Energy Efficient Motors - ENCON Scope. Transmission Line Parameters - Transmission Line Losses- Kelvin's Law Performance Calculation and Analysis	
UNIT III - FANS, PUMPS AND COMPRESSORS	(9)
Basics - Selection - Performance Evaluation - Cause for inefficient operation - scope for energy conservation - methods adopted for effecting ENCON - Economics of ENCON adoption.	
UNIT IV - STUDY OF ILLUMINATION AND ENERGY EFFICIENT DEVICES	(9)
Specification of luminaries - Types - Efficacy - Selection and Application - ENCON Avenues and Economic Proposition - New Generation Luminaries (LED - Induction Lighting) - Soft Starters- Auto Star - Delta - Star Starters- APFC - Variable Speed and Frequency Drives - Time Sensors - Occupancy Sensors.	

UNIT V - CO2 MITIGATION AND CASE STUDIES	(9)
Evaluation for 3 / 4 Typical Sectors - PAT Scheme (an introduction) - CO_2 Mitigation - Energy Conservation - Cost Factor. Case Studies on Industrial Energy Audit.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Energy-Efficient Shutdown of Circuit Components and Computing Systems, by EhsanPakbaznia, Proquest, Umi Dissertation Publishing (1 September 2011) ,ISBN-10 : 1243819898
2. Handbook on Energy Efficiency, TERI, New Delhi, 2001

REFERENCES:

1. Hamies, Energy Auditing and Conservation ; Methods Measurements, management and Case Study, Hemisphere, Washington, 1980
2. Trivedi, PR and Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001
4. Peters, Kraushaar and Ristenen, Sustainable Energy, beta - test - draft, Energy and Problems of a Technical Society, 1993
5. Guide book for National Certification Examination for Energy Managers and Energy Auditors (www.energymanagertraining.com)
6. Nagrath IJ and Kothari DP, Power system engineering, TMH, 2007

17MEX48 GREEN SUPPLY MANAGEMENT					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To familiar the various standards and legislation of modern electronic manufacturing.	1.1	Get concise awareness of standards and legislation of modern electronic manufacturing for green environment.	a,b,c,g,l,k,l
2.0	To know the conventional electronic processing and lead-free electronic manufacturing techniques.	2.1	Explain the conventional electronic processing and lead free electronic manufacturing techniques.	a,b,c,g,l,k,l
3.0	To recognize the steps involved in assembly process and understand the need of recycle the electronics	3.1	Realize the assembly process and the need of recycle of electronics	a,b,c,g,l,k,l
4.0	To implement reliability and product life cycle estimation tools in green electronic manufacturing.	4.1	Use reliability and product life cycle estimation tools for electronic manufacturing.	a,b,c,g,l,k,l
5.0	To demonstrate the green electronic manufacturing procedure in applications.	5.1	Validate the green electronic manufacturing procedures in applications.	a,b,c,g,l,k,l

UNIT I - INTRODUCTION TO GREEN ELECTRONICS	(9)
Environmental concerns of the modern society- Overview of electronics industry and their relevant regulations in China, European Union and other key countries- global and regional strategy and policy on green electronics industry. Restriction of Hazardous substances (RoHS) - Waste Electrical and electronic equipment (WEEE - Energy using Product (EuP) and Registration - Evaluation, Authorization and Restriction of Chemical substances (REACH).	
UNIT II - GREEN ELECTRONICS MATERIALS AND PRODUCTS	**(9)**
Basics of IC manufacturing and its process - Electronics with Lead (Pb) -free solder pastes, conductive adhesives, Introduction to green electronic materials and products - halogen-free substrates and components. Substitution of non-recyclable thermosetting polymer based composites with recyclable materials X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products	
UNIT III - GREEN ELECTRONICS ASSEMBLY AND RECYCLING	**(9)**
Various processes in assembling electronics components - the life-cycle environmental impacts of the materials used in the processes - substrate interconnects. Components and process equipments - Technology and management on e-waste recycle system construction, global collaboration, and product disassembles technology.	

UNIT IV - PRODUCT DESIGN AND SUSTAINABLE ECO-DESIGN	(9)
Stages of product development process in green design: Materials- Manufacturing - Packaging and use - End of Life and disposal - Design for recycling - Life Cycle Assessment (LCA), and Eco-design tools - Environmental management systems, and International standards - Eco-design in electronics industry.	
UNIT V - CASE STUDIES	(9)
Reliability of green electronics systems , Reuse and recycle of End-of-Life(EOL) electrical and electronic equipment for effective waste management - Introduction of Green Supply Chain, and Modeling green products from Supply Chain point of view - A life-cycle assessment for eco-design of Cathode Ray Tube Recycling.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. Green Supply Chain Management, by CharisiosAchillas , Dionysis D. Bochtis , DimitriosAidonis, Routledge; 1st edition (16 November 2018), ISBN-10 : 1138644617
2. Sammy G. Shina, Green Electronics Design and Manufacturing, McGraw Hill., 2008.

REFERENCES:

1. David Austen, Green Electronic Morning, Ingleby Gallery, 2006.
2. John Hu. Mohammed Ismail, CMOS High Efficiency on - Chip Power Management, Springer Publications 4th edition, 2011.
3. Yuhang yang and Maode Ma, Green Communications and Networks, Springer Publication., 2014.
4. SankaGanesan, Michael Pecht, Lead free Electronics, John Wiley & Sons, 2006.
5. Charles A. Harper, Electronic Materials and Processes Hand book, McGraw-Hill, 2010.
6. Sammy G. Shina, Green Electronics Design and Manufacturing, McGraw Hill., 2008.

17MEX49 AUTOMOTIVE MATERIALS, COMPONENTS, DESIGN AND TESTING				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To describe the functional requirements of engine components and suitable materials	1.1	Demonstrate the requirements of engine components and select suitable materials.	a,b,c,d,l
2.0	To design cylinder and piston components	2.1	Apply the concept of design to cylinder and piston components and solve problems.	a,b,c,d,l
3.0	To design connecting rod and crank shaft	3.1	Apply the concept of design to Connecting rod and crank shaft and solve problems.	a,b,c,d,l
4.0	To design of flywheel and valve train	4.1	Apply the concept of design to flywheel and valve train and solve problems.	a,b,c,d,l
5.0	To describe the Engine Testing cycles, Emission measurement technologies	5.1	Demonstrate engine teste cycles, dynamometer and emission measurement technologies and instruments	a,b,c,d,l

UNIT - I FUNCTIONAL REQUIREMENTS OF ENGINE COMPONENTS AND SUITABLE MATERIALS	6
Functional requirements of engine components - Piston, piston pin, cylinder liner, connecting rod, crank shaft, valves, spring, engine block, cylinder head, and flywheel. Suitable materials for engine components.	
UNIT - II DESIGN OF CYLINDER AND PISTON COMPONENTS	**6**
Design of cylinder, cylinder head, piston, piston rings and piston pin	
UNIT - III DESIGN OF CONNECTING ROD AND CRANK SHAFT	**6**
Design of connecting rod - Shank design - small end design - big end design - bolts design. Design of overhang crank shaft under bending and twisting - Crank pin design - Crank web design - Shaft design.	
UNIT - IV DESIGN OF FLYWHEEL AND VALVE TRAIN	**6**
Design of valve - inlet valve - exhaust valve - Valve springs - tappet - rocker arm. Determination of mass of flywheel for a given coefficient of fluctuation of speed. Design of flywheel - rim - hub - arm.	
UNIT - V ENGINE TESTING	**6**
Engine test cycles - Worldwide harmonized Light-duty vehicles Test Cycles ((WLTC) - World Harmonized Stationary Cycle (WHSC) - World Harmonized Vehicle Cycle (WHVC) - Nonroad Transient Cycle (NRTC) - ISO 8178. Dynamometer - Chassis dynamometer - transient dynamometer. Emission measurement technologies and instruments - NO_X - Smoke - Particulate matter - CO - CO_2 - HC.-Particle counter	
TOTAL (L:30 + P:30) = 60 PERIODS	

Approved by Eleventh Academic council

EXPERIMENTS

1. Design and animate Piston Cylinder assembly and motion study using CAD software.
2. Design and simulate Connecting rod and crank shaft
3. Design flywheel and valve
4. Design and simulate Two Cylinder Engine assembly using CAD software.
5. Conduct the engine performance test
6. Conduct the emission test

TEXT BOOK:
1. Khurmi. R.S. & Gupta. J.K., "A text book of Machine Design", Eurasia Publishing House (Pvt) Ltd, 2001. 2. The Automotive Chassis: Volume 1: Components Design (Mechanical Engineering Series) by Giancarlo Genta and Lorenzo Morello | 24 December 2019
REFERENCES:
1. Hiroshima Yamagata, “The science and technology of materials in automotive engines”, Woodhead Publishing Limited, Cambridge, England. 2. Jain.R.K, “Machine Design”, Khanna Publishers, New Delhi, 2005 3. Manufacturing Automotive Components from Sustainable Natural Fiber Composites (SpringerBriefs in Materials) by Lobna A. Elseify, MohamadMidani, et al. | 9 August 2021 4. Mechanical and Materials Engineering of Modern Structure and Component Design (Advanced Structured Materials Book 70) by Andreas Öchsner and Holm Altenbach | 6 June 2015 5. Advanced Technology for Design and Fabrication of Composite Materials and Structures: Applications to the Automotive, Marine, Aerospace and ... Applications of Fracture Mechanics) by George C. Sih, Alberto Carpinteri, et al. | 15 December 2010

WEB RESOURCES
https://tinyurl.com/mrwpjtbz https://tinyurl.com/464ndbeh https://tinyurl.com/4t4ukv6m

17MEX50 CONVENTIONAL AND FUTURISTIC VEHICLE TECHNOLOGY				
L	T	P	C	
3	0	0	3	
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To learn various advanced combustion technologies and its benefits	1.1	Demonstrate the need of advanced combustion technologies and its impact on reducing carbon foot-print on the environment.	a,b,l
2.0	To learn the methods of using low carbon fuels and its significance	2.1	Analyse the basic characteristics of low carbon fuels, its impact over conventional fuels and in achieving sustainable development goals.	a,b,l
3.0	To describe the advanced engine technologies	3.1	Demonstrate the latest trends in engine technology	a,b,l
4.0	To learn and understand the hybrid and electric vehicle configurations	4.1	describe the working and energy flow in various hybrid and electric configurations.	a,b,l
5.0	To study the application of fuel cell technology in automotives	5.1	Analyse the need for fuel cell technology in automotive applications.	a,b,l

UNIT – I COMBUSTION TECHNOLOGY	9
Spark Ignition combustion, Compression Ignition Combustion, Conventional Dual Fuel Combustion, Low Temperature Combustion Concepts- Controlled Auto Ignition, Homogeneous Charge Compression Ignition, Premixed Charge Compression Ignition, Partially Premixed Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition.	
UNIT – II LOW CARBON FUEL TECHNOLOGY	**9**
Alcohol Fuels, Ammonia Fuel and Combustion, Methane Technology, Dimethyl Ether, Hydrogen Fuel Technology, Challenges, and way forward	
UNIT – III ADVANCED ENGINE TECHNOLOGY	**9**
Gasoline Direct Injection, Common Rail Direct Injection, Variable Compression Ratio Turbocharged Engines, Electric Turbochargers, VVT, Intelligent Cylinder De-activation, After Treatment Technologies, Electric EGR, Current EMS architecture	
UNIT – IV HYBRID AND ELECTRIC VEHICLE (BATTERY POWERED)	**9**
Conventional Hybrids (Conventional ICE + Battery), Modern Hybrids (RCCI/GDCI Engine + Battery), Pure Electric Vehicle Technology – Challenges and Way forward	
UNIT – V FUEL CELL TECHNOLOGY	**9**
Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.	
TOTAL (L:45) = 45 PERIODS	

TEXT BOOKS:
1. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004 2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines. ISBN 978-3-319-68507-6, SPRINGER
REFERENCES:
1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. 2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003 3. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley & Sons, 1998 4. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. 5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003

17MEX51 RENEWABLE POWERED OFF HIGHWAY VEHICLES AND EMISSION CONTROL TECHNOLOGY				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

	Course Objectives		Course Outcomes	Related Program outcomes
1.0	To study the low and zero carbon fuels suitability and methods of use in off-road vehicles	1.1	Select suitable low and zero carbon fuels for off-highway vehicles.	a,b,c,d,e,l,l
2.0	To learn and understand the green energy production methodologies and its use in off-road vehicle categories	2.1	Demonstrate green energy technologies and its applications in off road vehicles.	a,b,c,d,e,l,l
3.0	To learn various fuel cell types and its suitability in off-highway vehicles applications	3.1	Select the suitable fuel cell for Off-Highway vehicles	a,b,c,d,e,l,l
4.0	To illustrate the impact of in-cylinder technologies on engine out emissions control	4.1	Demonstrate in-cylinder low temperature combustion technologies and its key role in controlling the engine-out emissions.	a,b,c,d,e,l,l
5.0	To study the existing after-treatment technologies used in off-highway vehicle applications	5.1	Demonstrate the working of various after treatment systems in controlling the engine out emissions.	a,b,c,d,e,l,l

UNIT – I LOW AND ZERO CARBON FUELS POWERED OFF-HIGHWAY VEHICLES	9
Ethanol, Methanol, Butanol, Biodiesel, Compressed natural gas,liquefied natural gas, Dimethyl ether, Polyoxymethylene Dimethyl Ether, Ammonia and Hydrogen Fuels suitability, methods, and technologies for powering off-road vehicles.	
UNIT – II GREEN ENERGY POWERED OFF-HIGHWAY VEHICLES	9
Solar Technology for Green Electricity, Green Electricity for Hydrogen Production, Hydrogen Smart Grid Technologies, Hydrogen to ICE powered vehicles, Hydrogen to Fuel Cell Powered Vehicles.	
UNIT – III FUEL CELL POWERED OFF-HIGHWAY VEHICLES	9
Fuel Cell, Types, Applications, Fuel Cell Requirement, Sizing and Design for Off-Highway applications, Merits and Demerits, Pathway to overcome the limitations. Scope of the fuel cell research on Off-road vehicle applications.	
UNIT – IV IN-CYLINDER TREATMENT TECHNOLOGIES	9
Low temperature Combustion Modes - Homogeneous Charge Compression Ignition, Premixed-Charge Compression Ignition, Reactivity Controlled Compression Ignition, Gasoline Direct Injection Compression Ignition, Water Injection Technologies.	
UNIT – V AFTER TREATMENT TECHNOLOGIES	9
Diesel Oxidation Catalyst, Diesel Particulate Filter, Selective Catalytic Reduction, Ammonia slip / clean up catalyst. CO_2 absorption techniques, Waste Heat Recovery and Organic Rankine Cycle.	
TOTAL 45 PERIODS	

TEXT BOOKS:
1. John Twidell, and Tony Weir. Renewable Energy Sources - 3rd Edition 2015 2. Rakesh Kumar Maurya, Characteristics and Control of Low Temperature Combustion Engines.
REFERENCES:
1. Daniel J Holt. Fuel Cell Powered Vehicles: Automotive Technology of the Future. Society of Automotive Engineers, 2001 - Technology & Engineering, 2. W. AddyMajewski, Magdi K. Khair. Diesel Emissions and Their Control. 3. Toward Zero Carbon: The Chicago Central Area DeCarbonization Plan by Adrian Smith and Gordon Gill | 1 June 2011 4. Transportation in a Net Zero World: Transitioning Towards Low Carbon Public Transport (Green Energy and Technology) by Kathryn G. Logan, Astley Hastings, et al. | 7 April 2022 5. The Political Economy of Low Carbon Transformation: Breaking the habits of capitalism (Routledge Studies in Low Carbon Development) by Harold Wilhite | 21 December 2017

17MEX52 VEHICLE HEALTH MONITORING, MAINTENANCE AND SAFETY				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To enable the student to understand the principles, functions and practices adapted in maintenance activities of vehicles	1.1	Demonstrate the general maintenance and monitoring of vehicle	a,b,c,d,e,l,l
2.0	To study the power train maintenance, fault diagnosis, maintenance of Batteries	2.1	Demonstrate powertrain tests and its maintenance.	a,b,c,d,e,l,l
3.0	To develop vehicle system maintenance and service of clutch, brake	3.1	Demonstrate the maintenance of braking systems, steering and wheels	a,b,c,d,e,l,l
4.0	To study the concepts of vehicle safety and regulations.	4.1	Demonstrate various vehicle safety features.	a,b,c,d,e,l,l
5.0	To study and understand the simulation of safety concepts	5.1	Demonstrate the simulation of safety concepts.	a,b,c,d,e,l,l

UNIT – I GENERAL MAINTENANCE OF VEHICLE	9
Need for Maintenance – importance, classification of maintenance work-basic problem diagnosis. Maintenance of vehicle systems – power pack, tyres, safety systems. Scheduled maintenance services – service intervals – On-board diagnostics(OBD), Computerized engine analyzer study and practice- OBD I & II and scan tools;	
UNIT – II POWERTRAIN MAINTENANCE	**9**
Exhaust emission test of petrol and diesel engine; - Electronic fuel injection and engine management service - fault diagnosis- OBD-III and scan tool, identifying Diagnostic Trouble Code(DTC) and servicing emission controls, Maintenance of Batteries, Starting System, Charging System and Body Electrical -Fault Diagnosis Using Scan Tools.	
UNIT – III VEHICLE SYSTEM MAINTENANCE	**9**
Clutch- adjustment and service, Maintenance and Service of Hydraulic brake, Bleeding of brakes, Checking Anti-lock Braking System(ABS) and components. Maintenance and Service of McPherson strut, coil spring. tyre wear, measurement of read depth and tyre rotation, Computerized wheel balancing & wheel alignment, Maintenance and Service of steering linkage, steering column, Rack and pinion steering	
UNIT – IV VEHICLE SAFETY	**9**
Concepts of vehicle safety -Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, air bags, electronic system for activating air bags, bumper design for safety, Active Safety - ABS, Electronic Brake-force Distribution(EBD), Cornering Stability Control (CSC), Traction control system, Modern electronic features in vehicles like tyre pressure monitoring, Automatic headlamp ON, Rain sensing wipers.	

UNIT - V SIMULATION OF SAFETY CONCEPTS	9
Active safety: driving safety, conditional safety, perceptibility safety, operating safety passive safety: exterior safety, interior safety, deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact. Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system Interactions.	
	TOTAL 45 PERIODS

TEXT BOOKS:

1. 5th Edition, “Advanced Automotive Fault Diagnosis Automotive Technology: Vehicle Maintenance and Repair” By Tom Denton
2. Safety Management System and Documentation Training Programme Handbook by S. V. Paul ISBN: 9788123923444

REFERENCES:

1. Ed May, "Automotive Mechanics Volume One" and Two, McGraw Hill Publications, Tenth edition, 2018
2. Bosch Automotive Handbook, Tenth Edition, 2018
3. Jack Erjavek, “A systems approach to Automotive Technology”, Cengage Learning, 5th Edition, 2012
4. William H. Crouse and Donald L. Anglin, “Automotive Mechanics”, Tata McGraw Hill, 10thEdition, 2004.
5. Vehicle Service Manuals of Reputed Indian Manufacturers

17MEX53 CAE AND CFD APPROACH IN FUTURE MOBILITY				
	L	T	P	C
	3	0	0	3
PREREQUISITE:NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To study the use of computer in mobility software or mobility.	1.1	Demonstrate the basic concept of the CAE /CFD	a,b,c,d,e,g,l,l
2.0	To study the concepts computer aided design and rapid prototyping	2.1	Develop the computer aided design and rapid prototyping.	a,b,c,d,e,g,l,l
3.0	To introduce the basic concepts of the finite elements methods.	3.1	Demonstrate the basic concept of Finite Element methods.	a,b,c,d,e,g,l,l
4.0	To introduce basics and fundamental of the computational fluid dynamics	4.1	Demonstrate the concepts of computational fluid dynamics	a,b,c,d,e,g,l,l
5.0	To introduce Turbulence Modeling and various simulation techniques	5.1	Solve the problem and simulate using computational fluid dynamics.	a,b,c,d,e,g,l,l

UNIT I : COMPUTER AIDED ENGINEERING AND COMPUTATIONAL FLUID DYNAMICS	(9)
Introduction to use of computer in Mobility Product Life Cycle, Software for mobility. Introduction to designprocess and role of computers in the design process, use of modern computational tools used for design and analysis, Concept of modeling and simulation. CFD as a design and research tool, Applications of CFD in mobility engineering	
UNIT II : CAD AND RAPID PROTOTYPING	**(9)**
Curves and Surfaces: Geometric modeling curves and surfaces, Wire frame models, Parametric representations, Parametric curves and surfaces, Mechanism design and assembly. CAD/CAM Data Exchange Formats: Types of file formats & their exchange, Graphics standards. CAD Data and Programming Techniques for RP: Transformations, Solid modeling for RP, Surface modeling, STL file generation, Defects in STL files and repairing algorithms, Interface formats	
UNIT III : FINITE ELEMENT ANALYSIS	**(9)**
Basic Concept of Finite Element Method, Ritz and Rayleigh Ritz methods, Method of weighed residuals, Galerkin method. Governing differential equations of one- and two dimensional problems, One Dimensional Second Order Equations - Discretization - Linear and Higher order Elements - Interpolation and shape functions, Derivation of Shape functions and Stiffness matrices and force vectors-Assembly ofMatrices - Solution of static problems and case studies in stress analysis of mechanical components using2D and 3D elements	
UNIT IV : COMPUTATIONAL FLUID DYNAMICS	**(9)**
CFD vs. experimentation; continuity, Navier-stokes and energy equations; modeling and discretization techniques; basic steps in CFD computation Various simplifications, Dimensionless equations and parameters, Incompressible inviscid flows, Source panel method, and Vortex panel method. Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching. 3-D structured and unstructured grid generation, mesh smoothing and sensitivity checks	

UNIT V : PROBLEM SOLVING USING CFD	(9)
Turbulence Modeling, different turbulent modeling scheme. Incompressible Viscous Flows, Applications to internal flows and boundary layer flows. Eddy viscosity and non-eddy viscosity models; Vehicle Aerodynamic Simulation Wind tunnel and on-road simulation of vehicles; Simulation of Ahmed and Windsor bodies; Vorticity based grid-free simulation technique; simulation in climatic and acoustic wind tunnels; velocity vector and pressure contour simulation	
TOTAL = 45 PERIODS	

TEXT BOOKS:

1. Versteeg, H.K., and Malalasekera, W.,"An Introduction to Computational Fluid Dynamics": The finite volume Method, Pearson Education, 2014
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill, 1998.

REFERENCES:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill Publishing Co.2007
2. Groover, M. P., CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education, 2008
3. TirupathiR.Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.
4. Dhanaraj. R and Prabhakaran Nair. K, "Finite Element Analysis", Oxford Publications, 2015.

17MEX54 HYBRID AND ELECTRIC VEHICLE TECHNOLOGY				
	L	T	P	C
	3	0	0	3
PREREQUISITE : NIL				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the concept of hybrid and electric drive trains.	1.1	Demonstrate hybrid and electric drive trains.	a,b,c,d,e,g,l
2.0	To elaborate on the types and utilization of hybrid and electric drive trains.	2.1	Design and apply appropriate hybrid and electric drive trains in a vehicle	a,b,c,d,e,g,l
3.0	To expose on different types of AC and DC drives for electric vehicles.	3.1	Design and install suitable AC and DC drives for electric vehicles.	a,b,c,d,e,g,l
4.0	To learn and utilize different types of energy storage systems	4.1	Demonstrate suitable energy storage system for a hybrid / electric vehicle	a,b,c,d,e,g,l
5.0	To introduce concept of energy management strategies and drive sizing	5.1	Apply energy management strategies to ensure better economy and efficiency	a,b,c,d,e,g,l

UNIT I : INTRODUCTION TO HYBRID AND ELECTRIC VEHICLES	(9)
Basics of vehicle performance, vehicle power source characterization, transmission characteristics, History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.	
UNIT II : HYBRID ELECTRIC DRIVE TRAINS	(9)
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.	
UNIT III : CONTROL OF AC & DC DRIVES	(9)
Introduction to electric components used in hybrid and electric vehicles, Configuration, and control - DC Motor drives, Induction Motor drives, Permanent Magnet Motor drive, and Switch Reluctance Motor drives, drive system efficiency.	
UNIT IV : ENERGY STORAGE	(9)
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Energy storage and its analysis - Battery based, Fuel Cell based, and Super Capacitor based, Hybridization of different energy storage devices	

UNIT V : DRIVE SIZING AND ENERGY MANAGEMENT STRATEGIES	(9)
Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selection of appropriate energy storage technology, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification, and comparison of energy management strategies, Implementation issues.	
TOTAL = 45 PERIODS	

TEXT BOOK:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals,ThirdEdition,2021
2. James Larminie, John Lowry, Electric VehicleTechnologyExplained,Wiley,2003

REFERENCES:

1. Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Rand D.A.J, Woods, R & Dell RM Batteries for Electric vehicles, John Wiley &Sons,1998
3. Hybrid, Electric and Fuel-Cell Vehicles, International Edition by Jack Erjavec June2012
4. Energy Management in Hybrid Electric Vehicles using Co-Simulation by Christian Paar |11February2011

17MEM03 MATERIALS FOR ELECTRIC VEHICLES					
		L	T	P	C
		3	0	0	3
PREREQUISITE: NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To provide the knowledge about the chassis types and materials of the vehicle.	1.1	Able to understand the different chassis and materials used in EV	a, b, l, k, i
2.0	To acquire the knowledge of battery types and materials	2.1	Know the battery types and materials	a, b, l, k, i
3.0	To learn the basic concept of motor, brake and semiconductor materials	3.1	Select the materials for motor, brake and semiconductor.	a, b, l, k, i
4.0	To study the manufacturing process in the batteries.	4.1	Explain the manufacturing process of the batteries.	a, b, l, k, i
5.0	To understand the basis of materials and testing	5.1	Acquire the concept of basis of materials and testing	a, b, l, k, i

UNIT I : CHASSIS TYPES AND MATERIALS	(9)
Overview of materials, Introduction to chassis, types- Conventional chassis, Non-conventional chassis, Full forward chassis, Semi-forward chassis, Bus chassis, Engine at front chassis, Rear chassis and Center chassis. Chassis materials	
UNIT II : BATTERIES TYPES AND MATERIALS	**(9)**
Types of Batteries, materials- Batteries-Lithium-ion battery & Lead acid battery basics, Special characteristics of lead acid batteries, Battery life and maintenance, Battery charging, Summary, Nickel-based Batteries-Introduction, Nickel cadmium, Nickel metal hydride batteries, battery packaging materials, Battery pack encapsulation materials, fire retardant grade materials.	
UNIT III : MATERIALS FOR MOTORS, BRAKES & SEMICONDUCTORS	**(9)**
Introduction of motor, types, materials for rotor, stator, body, armature, shaft, bearings, Introduction to brake, types, selection of brake materials. Neodymium permanent magnets, Hydrogen compatible Materials – Metals and Polymers, Semiconductor materials	
UNIT IV : MANUFACTURING OF BATTERIES	**(9)**
Introduction to manufacturing of batteries, battery production process-electrode manufacturing, mixing, coating & drying, calendaring, slitting, cell assembly-notching, stacking, pouch assembly - Forming, aging and validation.	
UNIT V : MATERIALS AND TESTING	**(9)**
Classification of material testing, Purpose of testing, Selection of material, Development of testing, Testing organizations and its committee, Testing standards, Result Analysis, Advantages of testing.	
	TOTAL (L:45) : 45 PERIODS

TEXT BOOKS:
1. Vladimir Kobelev, “Design and Analysis of Composite Structures for Automotive Applications Chassis and Drivetrain”Wiley, 2019. 2. Austin Hughes, William Drury, “Electric Motors and Drives: Fundamentals, Types and Applications”, 4th ed., Newnes, 2013.
REFERENCES:
1. Metals Handbook: Mechanical testing, (Volume 8) ASM Handbook Committee, 9th Edition, American Society for Metals, 1978. 2. Guangjin Zhao, “Reuse and Recycling of Lithium-Ion Power Batteries”, John Wiley & Sons. 2017. 3. Keisuke Fujisaki, “Magnetic material for motor drive system: fusion technology of electromagnetic fields”, Springer, 1st ed., 2019. 4. Brian Cantor, P. Grant, C. Johnston, “Automotive engineering: lightweight functional and novel materials”, Taylor & Francis, 2008

17MEM04 POWERTRAIN DESIGN FOR ELECTRIC VEHICLES					
		L	T	P	C
		3	0	0	3
PREREQUISITE: NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the types of structure, construction details and working principle of EV	1.1	Know the structure, components of an electric vehicles and it types	a, b, c, d, e, f, I, k, i
2.0	To learn about the design of different electric motor for drives	2.1	Describe the working principles of electric motors and functions	a, b, c, d, e, f, I, k, i
3.0	To learn about the various types of transmission systems	3.1	Classify the types of transmission systems	a, b, c, d, e, f, I, k, i
4.0	To acquire knowledge on auxiliary system, steering, brakes and suspension	4.1	Explain the working principles of steering, braking and suspension systems	a, b, c, d, e, f, I, k, i
5.0	To know the electric vehicles safety and types of advanced technologies	5.1	Summarize the safety and types of advanced technologies	a, b, c, d, e, f, I, k, i

UNIT I : COMPONENTS OF EV	(9)
Vehicle construction - chassis - frame and body - aerodynamics, resistances and Moments - battery - power converter - Electric motor - generator, inverter - Rectifier - coupler - controller - Pure Electric vehicles - Hybrid electric vehicles - Plug in Hybrid Electric vehicle	
UNITII : ELECTRIC DRIVE SYSTEM	**(9)**
Introduction-Transfer function for DC motor / load and converter - Closed loop control with Current and speed feedback-Armature voltage control and field weakening mode - DC Series Motor - Induction motors - Brushless DC Motor - Permanent Magnet Synchronous Motor (PMSM) - Three Phase AC Induction Motors - Switched Reluctance Motors (SRM)	
UNIT III :TRANSMISSION SYSTEM	**(9)**
E pedal - Electric power converter -Electric booster - power train controller - Drive power - Torque converter - Reduction gear-Power split device- driveshaft - differential - axles - Drive wheels	
UNIT IV : STEERING, BRAKES AND SUSPENSION SYSTEM	**(9)**
Principle of steering - steering geometry - steering linkages - steering gear box - power steering - brakes - types and construction - drum brake, disc brake, pneumatic braking system, hydraulic braking system and antilock braking system (ABS) - types of front and rear axle - suspension system - types and construction - coil spring, leaf spring, stabilizer bars - air suspension - shock absorber	
UNIT V :SAFETY SYSTEMS & ADVANCED TECHNOLOGY	**(9)**
Air bags - Electronic Brake Distribution (EBD) - Electronic Stability Program (ESP) - Traction Control System (TCS) - Global Positioning System (GPS) - Collision avoiding system, - Tyre pressure monitoring system (TPMS), Cruise controller - driver information system - Advanced driver assistance systems (ADAS), Autonomous vehicles - IoT, Connected cars, Cyber Physical System (CPS)	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:
1. William H. Crouse and Donald L Anglin, “Automotive Mechanics”, 10th ed., McGraw Hill Education (India) Private Limited, 2006. 2. Babu.A.K and Ajit Pal Singh, “Automobile Engineering”, 1st ed., S.Chand Publications, 2013.
REFERENCES:
1. Ronald K Jurgen, “Automotive Electronics Handbook”, McGraw Hill, Inc, 1999. 2. Tom Denton, “Automobile Electrical and Electronic Systems”, Edward Arnold publications, 1995 3. Don Knowles, Don Knowles, Prentice Hall, Englewood Cliffs, “Automotive Electronic and Computer controlled Ignition Systems”, New Jersey 1988. 4. William, T.M., “Automotive Electronic Systems”, Heiemann Ltd., London, 1978. 5. Kirpal Singh, “Automobile Engineering Vol.1 & 2”, Standard Publishers, New Delhi, 2011 6. VijayakumarGali, LucianeNevesCanha, Mariana Resener, BibianaFerraz, Madisa V.G. Varaprasad “Advanced Technologies in Electric Vehicles Challenges and Future Research Developments” Academic Press, 1st ed., 2023 7. Marco Mileti, Patrick Strobl, Hermann Pflaum, Karsten Stahl, “Design of a Hyper-High-Speed Powertrain for EV to Achieve Maximum Ranges”, Springer Berlin Heidelberg, 2023

17MEM05 BATTERY MANAGEMENT					
		L	T	P	C
		3	0	0	3
PREREQUISITE: NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce learner about batteries and its parameters.	1.1	Calculate the various parameters of battery and battery pack.	a,b,c,d,e,k
2.0	To infer knowledge on operational factors of battery technology.	2.1	Interpret the operational factors associated with battery systems.	a,b,c,d,e,k
3.0	To acquire the knowledge on lead acid batteries.	3.1	Formulate the design procedure for lead acid batteries.	a,b,c,d,e,k
4.0	To understand the battery management system and life prediction of batteries.	4.1	Identify the requirements of Battery Management System.	a,b,c,d,e,k
5.0	To gain knowledge on traction batteries and miscellaneous applications of batteries.	5.1	Familiarize different kinds of traction batteries.	a,b,c,d,e,k

UNIT I : INTRODUCTION TO BATTERIES	(9)
Types of Batteries - Energy conversion in batteries - Battery components - Principle of operation - Electrode selection -Calculating battery cell voltage - Battery cell voltage and Nernst equation – Cell balancing - Electrolyte for batteries - Gibbs free energy and battery voltage - Theoretical battery capacity - Practical energy of a battery - Specific energy and power.	
UNIT II : OPERATIONAL FACTORS OF BATTERY SYSTEMS	(9)
Performance parameters - Battery voltage -Secondary battery systems - Battery limiting factors - Battery current modes of discharge - Discharge current effect on voltage - Discharge current effect on capacity - The effect of temperature on battery performance - Self discharge - Calendar and Cycle Life - Internal resistance - safety - Battery selection – Battery testing.	
UNIT III : LEAD ACID BATTERIES & LITHIUM-ION BATTERIES	(9)
Introduction - Principle of operation-Types of lead acid & Lithium-Ion batteries - Cell components and fabrication - Failure modes -Charge process - Discharge process – Electrolyte - State of charge (SOC) - Capacity - Cycle life – Self discharge. Applications: Telecommunications and UPS, solar and wind energy storage.	
UNIT IV : IV BATTERY MANAGEMENT AND LIFE PREDICTION	(9)
Definitions: Battery management and battery life prediction - Monitoring & measuring, SOH - Battery management functions: Charge management, discharge management, safety management and smart battery system – Thermal run away - Life Prediction, Recycling of EV Battery	
UNIT V:TRACTION BATTERIES	(9)
Introduction to electric vehicles and hybrid electric vehicles - Battery technology for traction: Lead Acid , Nickel Cadmium, Nickel Metal Hydride, Lithium Ion, Lithium Polymer Batteries, Sodium Nickel Chloride Battery.Miscellaneous applications of batteries: Tracking Systems, Toll Collection, Oil Drilling, Car Accessories, Oceanography.	
TOTAL (L:45) : 45 PERIODS	

Text Books :
1. DavideAndrea , Battery Management Systems for Large Lithium-Ion Battery Packs, Artech House Publishers, London, First ed., 2010. 2. M. Broussely, G. Pistoia, Industrial Applications of Batteries From Cars to Aerospace and Energy Storage, Elsevier Publishers, The Netherlands, First ed., 2007.
References :
1. Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, Electrochemical power sources: batteries, fuel cells, and super capacitors, John Wiley & Sons, Inc., Hoboken, New Jersey, First ed., 2015. 2. Slobodan Petrovic, Battery Technology Crash Course A Concise Introduction, Springer Nature Switzerland AG, First ed., 2021. 3. Kiehne, H.A. Battery Technology Handbook, Dekker Publishers, New York, Second Revised ed., 2007. 4. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, Kindle ed., 2015. 5. Valer Pop , Henk Jan Bergveld , Dmitry Danilov , Paul P. L. Regtien , Peter H. L. Notten, “Battery Management Systems”, Springer, 2008

17MEM06 AI AND IOT FOR ELECTRIC VEHICLES					
		L	T	P	C
		3	0	0	3
PREREQUISITE: NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the fundamentals of IoT	1.1	Understand the concepts of IoT.	a,e
2.0	To introduce learner about AI and its fundamentals.	2.1	Familiarize the fundamentals of AI.	a,e
3.0	To impart the knowledge on AI and IoT applications in battery.	3.1	Explain the applications of AI and IoT in battery.	a,b,c,d,e,f
4.0	To gain knowledge on AI in EV design.	4.1	Demonstrate the applications of AI in EV design and power supply.	a,b,c,d,e,f
5.0	To infer knowledge on recent case studies.	5.1	Gain knowledge on real time applications of AI on EV.	a,b,c,d,e,f

UNIT I : INTRODUCTION TO INTERNET OF THINGS	(9)
Characteristics of IoT, Physical and logical design of IoT - IoT enabling technologies - Wireless sensor networks - Cloud computing - Big data analytics - Communication protocols - Embedded systems - Functional blocks - Communication models and APIS - IoT levels and deployment templates - Overview of microcontroller, sensors and actuators	
UNIT II : BASICS OF ARTIFICIAL INTELLIGENCE	(9)
Introduction to AI – Agents and Environments – Concept of rationality – Nature of environments – Structure of agents – Problem solving agents – Search algorithms – Uninformed search strategies – Data management and Data Munging	
UNIT III : AI AND IoT APPLICATIONS IN BATTERY	(9)
AI and IoT-Based Battery Management System for Electric and Hybrid Electric Vehicles- Monitoring of charging in industrial, commercial, and residential scenarios - health and temperature monitoring, monitoring of key parameters: voltage, current, temperature of battery – Monitoring of individual cells/group of cells	
UNIT IV : APPLICATIONS OF AI IN EV DESIGN AND POWER SUPPLY	(9)
AI in EV manufacturing, AI in electric vehicle design, modeling and optimization - Self driving EV Controlled with AI - advantages and limitations - AI in power supply management and life cycle assessment, CRISP - DM Method	
UNIT V : CASE STUDIES	(9)
Bosch – Google (Waymo) - Tesla - Autopilot – Audi - Jaguar - Land Rover - Toyota Guardian – FLIR.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOKS:

1. S. Angalaeswari, T. Deepa, L. Ashok Kumar, "Artificial Intelligence Applications in Battery Management Systems and Routing Problems in Electric Vehicles", IGS Global Publisher, 2023
2. A. Chitra, P. Sanjeevikumar, Jens Bo Holm-Nielsen, S. Himavath, "Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles", Wiley online library, 2020

REFERENCES:

1. Stuart Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach", 4th ed., Pearson Education, 2020.
2. SudipMisra, Anandarup, Mukherjee, Arijit Roy, "Introduction to IoT", Cambridge University Press, 1st ed., 2022
3. Arun MR, "Fundamentals of IoT", Notion press, 2022
4. https://link.springer.com/book/10.1007/978-981-19-2184-1
5. https://www.researchgate.net/publication/361251263_AI_and_ML_Powered_IoT_Applications_for_Energy_Management_in_Electric_Vehicles

17MEM07 AUTONOMOUS VEHICLES					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes		Related Program outcomes
1.0	To introduce the automated driving	1.1	Explain the concept of automated driving	a,b,i,l
2.0	To know about the advanced driver assistance systems	2.1	Understand the basic concept of advanced driver assistance systems	a,b,i,l
3.0	To learn and understand automated driving technologies	3.1	Develop the appropriate automated driving technology	a,b,i,l
4.0	To impart the knowledge of social and human issues	4.1	Know about the social and human issues	a,b,i,l
5.0	To learn and under the various case study	5.1	Apply the various case study	a,b,i,l

UNIT I :AUTOMATED DRIVING	(9)
Introduction to ADV - Safety - Vehicle and its occupants - IMI TechSafe, Regulation and Safety aspects of AV, Levels of automation	
UNIT II : ADVANCED DRIVER ASSISTANCE SYSTEMS	(9)
Introduction to ADAS - Example Systems - Adaptive Cruise control - Obstacle Avoidance Radar - Basic reversing aid - Radar -Stereo Video Camera - Rear Radar - Functional Safety and Risk.	
UNIT III : AUTOMATED DRIVING TECHNOLOGIES	(9)
Introduction - Road to Autonomy - Perception - Lidar Operation - Sensor Positioning - Automated Driving System - Mapping -Other technologies - Connectivity - Artificial Intelligence - Top-down and Bottom-up AI - Deep learning - End to End Machine Learning.	
UNIT IV : SOCIAL AND HUMAN ISSUES	(9)
Introduction - Public reaction to CAVs - Insurance - Mobility as a Service - Global Overview - UK - European union - US -Japan and china, External people and property - Service and repair	
UNIT V : CASE STUDIES	(9)
Nvidia - Bosch - Google (Waymo) - Tesla Autopilot - Nio, Xpeng, Arrival - Audi - Jaguar Land Rover - Toyota Guardian - FLIR - First sensor AG	
TOTAL (L:45) : 45 PERIODS	

Approved by Eleventh Academic council

TEXT BOOK:
1. Tom Denton “Automated Driving and Driver Assistance Systems” 1st ed., Routledge, Taylor & Francis Group, United Kingdom, 2020.
REFERENCES:
1. Maurer, Markus, J. Christian Gerdes, Barbara Lenz, and Hermann Winner., “Autonomous driving: technical, legal and social aspects” Springer Nature, 2016. 2. Coppola, Pierluigi, and DomokosEsztergár-Kiss., “Autonomous Vehicles and Future Mobility”, Elsevier, 2019. 3. Hussain T Mouftah, MelikeErol-kantarci and SameshSorour, “Connected and Autonomous Vehicles in Smart Cities” CRC Press, 1st ed., 2020. 4. Markus Maurer, J. Christian Gerdes, Barbara Lenz, Hermann Winner, “Autonomous Driving-Technical, Legal and Social Aspects”, Springer, 2016.

17MEM08 FUEL CELL TECHNOLOGY & SAFETY REGULATIONS			
L	T	P	C
3	0	0	3

PREREQUISITE: NIL

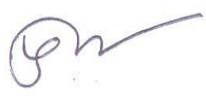
COURSE OBJECTIVES AND OUTCOMES:

	Course Objectives		Course Outcomes	Related Program outcomes
1.0	To introduce the working of fuel cells and their types	1.1	Understand the working of different types of fuel cells	a,b,e,f,g,k,l
2.0	To provide knowledge on fuel cell components and their performance	2.1	Determine the performance characteristics of various fuel cell components	a,b,e,f,g,k,l
3.0	To impart the knowledge on fuel cell and other competing technologies	3.1	Analyse the applications of fuel cell and other competing technologies	a,b,e,f,g,k,l
4.0	To impart the knowledge of fuel cell applications in automotive field	4.1	Apply the fuel cells on automotive field	a,b,e,f,g,k,l
5.0	To teach the basics of safety regulations of EV	5.1	Apply the safety regulations in the designing of EV	a,b,e,f,g,k,l

UNIT I : INTRODUCTION TO FUEL CELLS	(9)
Introduction - working and types of fuel cell - low, medium and high temperature fuel cell, liquid and methanol types, proton exchange membrane fuel cell - blue-grey-green hydrogen - thermodynamics and electrochemical kinetics of fuel cells - Battery swapping, shared mobility, connected vehicles	
UNIT II : FUEL CELL COMPONENTS AND THEIR IMPACT ON PERFORMANCE	(9)
Membrane electrode assembly components, bi-polar plate, humidifiers and cooling plates - Fuel cell performance characteristics - current/voltage, voltage efficiency and power density, ohmic resistance, kinetic performance, mass transfer effects.	
UNIT III : FUEL CELL ANALYSIS	(9)
Introduction - Modelling of FCEV - Applications to fuel cell and other competing technologies on vehicles - SI engine fueled by natural gas and hydrogen and hybrid electric vehicle.	
UNIT IV : FUEL CELLS FOR AUTOMOTIVE APPLICATIONS	(9)
Fuel cells for automotive applications - technology advances in fuel cell vehicle systems- onboard hydrogen generation -liquid and compressed hydrogen - metal hydrides, fuel cell control system- - road map to market applications.	
UNIT V : SAFETY REGULATIONS OF EV AND FCEV	(9)
Introduction - EV Policy measures - ARAI standard and Regulations for EV, Electric Power Train Vehicles-Construction and Functional Safety Requirements, Electric Vehicle Charging Safety Guidelines, Charging Infrastructure for Electric Vehicles (EV), Safety Regulations of FCEV, European regulations	
TOTAL(L:45) = 45 PERIODS	

Approved by Eleventh Academic council

TEXT BOOKS:
1. FranoBarbir, " PEM Fuel Cells : Theory and practice", Elsevier Academic Press, USA, 2005 2. Matthew M. Mench, "Fuel Cell Engines", John Wiley & Sons, 2008
REFERENCES:
1. Andrew L. Dicks, David A. J. Rand, "Fuel Cell Systems Explained" 3rd Ed., Wiley 2018 2. Pasquale Corbo, FortunatoMigliardini, OttorinoVeneri, "Hydrogen Fuel Cells for Road Vehicles - Green Energy and Technology (GREEN)", Springer, 2011 3. GregorHoogers, "Fuel Cell Technology Handbook" CRC Press, 2003 4. https://e-vehicleinfo.com/electric-vehicles-in-india-arai-standards-and-regulation/ 5. https://powermin.gov.in/en/content/electric-vehicle



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22MEC02 - ENGINEERING GRAPHICS AND DRAFTING

L	T	P	C
3	0	2	4

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To Create the projection of points, lines and planes	**1.1**	The students will be able to construct the projection of points, lines and planes
2.0	To Develop the projection of Solid	**2.1**	The students will be able to develop projection of solids
3.0	To Solve problems in sectioning of solids and developing the surfaces	**3.1**	The students will be able to solve problems in sections of solids and development of surfaces
4.0	To Apply the concepts of orthographic and isometric	**4.1**	The students will be able to apply the concepts of isometric in engineering practice
5.0	To Draw engineering drawing by Modeling software with dimensions	**5.1**	The students will be able to draw Engineering drawing by Modeling software with dimensions

CONCEPTS AND CONVENTIONS (Not for Examination)	
Importance of graphics in engineering applications - use of drafting instruments - BIS conventions and specifications - size, layout and folding of drawing sheets - lettering and dimensioning – scales	
UNIT I- PROJECTION OF POINTS AND LINES	**(9)**
Principal planes - first angle projection - projection of points - projection of straight lines (only first angle projections) inclined to both the principal planes - determination of true lengths and true inclinations by rotating line method.	
UNIT II - FIRST ANGLE PROJECTION OF PLANE	**(9)**
Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.	
UNIT III - PROJECTION OF SOLIDS	**(9)**
Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to anyone of the principal plane and Parallel to another by rotating object method.	
UNIT IV - DEVELOPMENT OF SURFACES	**(9)**
Development of lateral surfaces of simple and sectioned solids - prisms, pyramids cylinder and cone.	
UNIT V – ISOMETRIC AND ORTHOGRAPHIC PROJECTIONS	**(9)**
Principles of isometric projection - isometric scale - isometric projections of lines, plane figures, simple solids and truncated solids - prisms, pyramids, cylinder, cone – free hand sketching of orthographic views from isometric views of objects.	

LIST OF THE EXPERIMENTS

1. Computer aided drafting of front and top views of the given isometric view.
2. Computer aided drafting of front and top views of cylinder and cone.
3. Computer aided drafting of sectional views of prism and pyramid.
4. Draw the isomeric projection from given front and top views of the solid model.
5. 3D modeling of prism and pyramid
6. 3D modeling of spur gear.

TOTAL (L:45+P30) : 75 PERIODS

TEXT BOOKS:

1. K.Venugopal and V.Prabhu Raja, "Engineering Graphics", New Age International (P) Limited, 2022.
2. N.S Parthasarathy and Vela Murali, "Engineering Drawing", Oxford University Press, 2015.

REFERENCES:

1. N.D.Bhatt and V.M.Panchal, "Engineering Drawing", Charotar Publishing House, 53rd Edition, 2014.
2. K.R.Gopalakrishna., "Computer Aided Engineering Drawing" (Vol I and II combined) Subhas Stores, Bangalore, 2017.
3. K. V.Natarajan, "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2018.
4. Luzzader, Warren.J., and Duff, John M, "Fundamentals of Engineering Drawing with an introduction to Interactive Computer Graphics for Design and Production", Eastern Economy Edition, Prentice Hall of India Pvt Ltd, New Delhi, 2005.
5. M.B.Shah and B.C.Rana, "Engineering Drawing", Pearson, 2nd Edition, 2009.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	1	-	3	1	-	-	-	2	-	2	-	2
2	3	2	1	-	3	1	-	-	-	2	-	2	-	2
3	3	2	1	-	3	1	-	-	-	2	-	2	-	2
4	3	2	1	-	3	1	-	-	-	2	-	3	-	2
5	3	3	2	-	3	1	-	-	-	2	-	3	-	2
CO (W.A)	**3**	**2.2**	**1.2**	**-**	**3**	**1**	**-**	**-**	**-**	**2**	**-**	**2.4**	**-**	**2**

22MEC03 ENGINEERING MECHANICS (Mechanical Engineering Branch only)					
		L	**T**	**P**	**C**
		2	**1**	**0**	**3**
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To acquire knowledge on the behaviour of a particle under the action of forces	**1.1**	The students will be able to solve the engineering problems on resultant forces and particles under equilibrium conditions.		
2.0	To analyze the behaviour of the rigid body under the action of forces	**2.1**	The students will be able to calculate the reaction forces of various supports and resultant forces on rigid bodies		
3.0	To gain knowledge related to friction and simple contact friction	**3.1**	The students will be able to solve the problems involving dry friction of simple sliding systems and simple contact friction.		
4.0	To introduce the geometric properties of the different surfaces.	**4.1**	The students will be able to determine the centroid, centre of gravity and moment of inertia of various surfaces.		
5.0	To acquire knowledge work, energy and momentum related to dynamics of particles	**5.1**	The students will be able to solve the problems involving dynamics of particles.		

UNIT I - STATICS OF PARTICLE	**(6+3)**
Units and dimensions - fundamental principles - laws of mechanics, lami's theorem, parallelogram and triangular law of forces, principle of transmissibility – system forces - statics of particles in two dimensions - resultant force - coplanar concurrent forces - Free body diagram - equilibrium of particles in two dimensions.	
UNIT II - STATICS OF RIGID BODY	**(6+3)**
Statics of rigid body in two dimensions - rigid body - moment of a force about a point - varignon's theorem - resultant force for coplanar parallel and nonconcurrent forces - moments and couples - equilibrium of rigid bodies in two dimensions - requirements of stable equilibrium - types of supports and their reactions.	
UNIT III - FRICTION	**(6+3)**
Frictional force – limiting friction - angle of repose - coulomb's law of dry friction - cone of friction - problems involving the equilibrium analysis of simple systems with sliding friction - simple contact friction - ladder friction - belt friction.	
UNIT IV - PROPERTIES OF SECTIONS	**(6+3)**
Centroid – centre of gravity- Theorems of Pappus and Guldinus – moment of inertia of plane areas - transfer theorems - parallel axis and perpendicular axis theorem- radius of gyration- product of inertia - polar moment of inertia - principal axes and principal moment of inertia of plane areas.	
UNIT V - DYNAMICS OF PARTICLES	**(6+3)**
Kinematics - Displacements, velocity and acceleration, their relationship -rectilinear motion - curvilinear motion - projectile motion. Kinetics - Newton's law – D'Alembert's principle - impact of elastic bodies.	
TOTAL (L:30+T:15): 45 PERIODS	

TEXT BOOK:

1. Ferdinand P. Beer and E. Russell Johnson, "Vector Mechanics for Engineers: Statics and Dynamics", 12th ed., Tata McGraw Hill International Edition, 2019

REFERENCES:

1. Irving H. Shames, "Engineering Mechanics : Statics and Dynamics", Prentice Hall of India Private limited, 2006
2. Russell C Hibbeler, "Engineering Mechanics: Statics and Dynamics", 14th ed., Prentice Hall, 2016
3. Anthony M. Bedford and Wallace Fowler, "Engineering Mechanics: Statics and Dynamics", 5th ed., Prentice Hall, 2008
4. Palanichamy, M.S and Nagan,S, "Engineering Mechanics - Statics and Dynamics", 3rd ed., Tata McGraw-Hill, New Delhi, 2005
5. Meriam.J.L , Kraige.L.G, and Boltan, J.N "Engineering Mechanics: Statics and Dynamics", 9th ed., Wiley Publishers, 2020
6. Rajasekaran.S and Sankarasubramanian.G, "Fundamentals of Engineering Mechanics", 3rd ed., vikas Publishing House Pvt.Ltd. New Delhi, 2005.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	1	2	-	-	-	2	-	-	-	-	2	3	-
2	3	1	2	-	-	-	2	-	-	-	-	2	3	-
3	2	1	2	-	-	-	2	-	-	-	-	2	3	-
4	2	1	2	-	-	-	2	-	-	-	-	2	3	-
5	2	1	2	-	-	-	2	-	-	-	-	2	3	-
CO (W.A)	**2.4**	**1**	**2**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**3**	**0**

22MEC04 - ENGINEERING THERMODYNAMICS
(Use of Steam Tables and Psychrometric Chart permitted)

L	T	P	C
2	1	0	3

PREREQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To teach the basic concept of thermodynamics and applications of first law of thermodynamics	1.1	Describe the concepts of conservation of mass, conservation of energy, work interaction, heat transfer and first law of thermodynamics
2.0	To introduce the concept of second law of thermodynamics and entropy	2.1	Apply the concept of second law to analyze the performance of thermal equipments
3.0	To teach steps involved in analysis of gas power cycles	3.1	Determine the performance characteristics of air standard cycles
4.0	To provide knowledge on the process of steam formation at various conditions	4.1	Explain the stages in steam formation and determine the properties of steam
5.0	To impart the knowledge in Psychrometry and Psychrometric processes	5.1	Analyze the Psychrometric processes and determine the properties of air

UNIT I : BASIC CONCEPT, ZEROTH AND FIRST LAW OF THERMODYNAMICS **(6+3)**

Definitions - Thermodynamic systems - thermodynamic equilibrium - properties, state, process and cycle - point and path function - Zeroth law - reversible and Irreversible processes - energy, work and heat - internal energy - First Law - energy as a property of a system - PMM 1 - application of first law to closed system and steady Flow processes - applications of steady flow energy equation - steam turbine, centrifugal compressor, nozzle - limitations of first law.

UNIT II : SECOND LAW OF THERMODYNAMICS AND ENTROPY **(6+3)**

Second Law - performance of heat engines and reversed heat engines - reversible processes - statements of Second Law - PMM 2 - Clausius inequality - Carnot cycle - Carnot's theorem and corollary - entropy as a property of a system - entropy and irreversibility - entropy changes for a closed system and open system - Third Law of Thermodynamics.

UNIT III : GAS POWER CYCLES **(6+3)**

Air standard efficiency - Otto cycle - Diesel cycle - dual combustion cycle - Brayton cycle - work ratio - pressure ratio for maximum work - calculation of air standard efficiency.

UNIT IV : PROPERTIES OF PURE SUBSTANCES AND THERMODYNAMIC RELATIONS **(6+3)**

Pure substances - definition - phase change - p-T diagram - P-V-T surface - phase change terminologies - formation of steam - thermodynamic properties of steam - external work done during evaporation - internal latent heat - internal energy of steam - Entropy of water, evaporation, wet steam, superheated steam - Mollier diagram – Thermodynamic relations – Maxwell equations – TDS equations- heat capacities relations – energy equation – joule Thomson coefficient.

UNIT V : PSYCHROMETRY **(6+3)**

Concept of psychrometry and psychrometrices - psychrometric Relations - pressure, specific humidity, degree of saturation, relative humidity, enthalpy of moist air - Sling psychrometer - psychrometric charts - Psychrometric processes

TOTAL (L: 30 + T: 15) = 45 PERIODS

TEXT BOOKS:
1. Rajput.R.K, "A Textbook of Engineering Thermodynamics", 5th ed., Laxmi Publications, 2017
2. MichaelA.Boles,YunusA.Cengel,"Thermodynamics:AnEngineeringApproach",8th ed.,TataMcGraw-HillEducation,2017
REFERENCES:
1. Nag.P.K,"EngineeringThermodynamics",5th ed.,McGrawHillEducation,2013 2. Arora.C.P,Thermodynamics,TataMcGraw-HillEducation,2003 3. Moran,Shapiro,BoettnerandBailey"PrinciplesofEngineeringThermodynamics",8th ed.,WileyIndiaPvtLtd-2015 4. Holman.J.P,"Thermodynamics",10th ed.,McGrawHillEducation,2011 5. Rao.Y.V.C," An Introduction to Thermodynamics",RevisedEdition,OrientLongman,2009

Mapping of COs with POs / PSOs														
COs	**POs**												**PSOs**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	2		1				1	2	2	2	
2	3	3	2	2		1				1	2	2	2	
3	3	3	2	3		1				1	2	2	2	
4	3	3	2	2		1				1	2	2	2	
5	3	2	3	1		2				1	2	2	2	
CO (W.A)	**3**	**2.6**	**2.2**	**2**		**1.2**				**1**	**2**	**2**	**2**	

22MEC05 FLUID MECHANICS AND MACHINERY					
		L	T	P	C
		3	0	2	4
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			
1.0	To introduce the fundamentals of fluid mechanics and its properties	**1.1**	Demonstrate the fundamental concepts of fluid mechanics with different properties of fluids.		
2.0	To impart basic knowledge to determine major and minor losses in flow through pipes and boundary layer concept.	**2.1**	Calculate major and minor losses associated with pipe flow in piping networks.		
3.0	To give the fundamental knowledge on physical quantities and to predict the behavior of the prototype/model by applying model laws.	**3.1**	Predict the nature of physical quantities and to predict the behavior of the prototype/model by applying model laws.		
4.0	To introduce the types and working principles of hydraulic turbines and evaluate the performance of hydraulic turbines	**4.1**	Evaluate the performance of hydraulic turbines.		
5.0	To understand the functioning and characteristic curves of pumps	**5.1**	Demonstrate working principle and performance of centrifugal and recirocating pumps.		

UNIT I - FLUID PROPERTIES AND FLOW CHARACTERISTICS	**(9)+(3)**
Units and dimensions – Definition of fluids - Properties of fluids - mass density, specific weight, specific volume, specific gravity, viscosity, compressibility, vapour pressure, surface tension and capillarity. Flow characteristics -concept of control volume - application of continuity equation, energy equation and momentum equation. **Lab Experiments:** ➢ Verification of Bernoulli's equation ➢ Determination of the coefficient of discharge of given Orifice meter/ Venturimeter.	
UNIT II - FLOW THROUGH CIRCULAR CONDUITS	**(9)+(3)**
Laminar flow through circular conduits – Hagen Poiseuille equation - Boundary layer concepts -types of boundary layer thickness -Darcy Weisbach equation –friction factor - Moody diagram - minor losses - Flow through pipes in series and parallel - Hydraulic and energy gradient lines. **Lab Experiments:** ➢ Determination of friction factor for a given set of pipes ➢ Determination of minor losses in pipes	
UNIT III - DIMENSIONAL ANALYSIS AND SIMILITUDE	**(9)**
Fundamental dimensions - Dimensional homogeneity – dimensional analysis by using Buckingham's π theorem method - Similitude – types of similitude - Dimensionless parameters - application of dimensionless Parameters-Model analysis.	
UNIT IV - TURBINES	**(9)+(5)**
Classification of turbines -heads and efficiencies -velocity triangles. Axial, radial and mixed flow turbines. Pelton wheel, Francis turbine and Kaplan turbines - working principles - work done by water on the runner - unit quantities - Specific speed. **Lab Experiments:** ➢ Performance studies on Pelton wheel ➢ Performance studies on Francis turbine ➢ Performance studies on of Kaplan turbine	

UNIT V - PUMPS	(9)+(4)
Classification of Pumps - Centrifugal pumps-working principle - work done by the impeller - various efficiencies-velocity components at entry and exit of the rotor - velocity triangles - Reciprocating pump - working principle - work done. **Lab Experiments:** ➢ Performance studies on centrifugal pump ➢ Performance studies on reciprocating pump	
TOTAL (L:45 + P:15) = 60 PERIODS	

TEXT BOOK:

1. Bansal, R.K., Fluid Mechanics and Hydraulics Machines, Laxmi Publications (P) Ltd., New Delhi. 2019. Reviced 9th Edition (Unit I, II, III, IV, V)

REFERENCES:

1. Modi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, New Delhi 2019. 22nd Editon (Unit I, II, III, IV, V)
2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", John Wiley & Sons; 9th Edition SI Version 2015. (UNIT - I, II, III, IV, V)
3. Kumar. K.L., Engineering Fluid Mechanics, S Chand., New Delhi, 2016. 8th Edison (Unit I, II, III)
4. Streeter. V. L., and Wylie, E.B., Fluid Mechanics, McGraw Hill, 2017. 9th Edition (Unit I, II, III)
5. Rajput. R. K, "A text book of Fluid Mechanics and Hydraulic Machines", S. Chand & Company Ltd., New Delhi, sixth edition, 2010 (Unit I, II, III, IV, V).

WEB RESOURCES

https://nptel.ac.in/courses/105101082/
https://nptel.ac.in/courses/112105183/

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3							3	3		2	3	
2	3	3							3	3		2	3	
3	3	3	2						3	3		2	3	
4	3	3							3	3		2	3	
5	3	3							3	3		2	3	
CO (W.A)	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**2**	**3**	**-**

22MEC06 MANUFACTURING PROCESSES					
		L	T	P	C
		3	0	0	3
PREREQUISITE:					

Course Objectives		Course Outcomes	
1.0	To acquire knowledge on basic concepts of foundry and casting processes	**1.1**	Choose the suitable casting process to produce the simple casting components and prepare mould with core
2.0	To learn various metal joining processes and gain welding skills.	**2.1**	Categories and select appropriate metal joining process
3.0	To provide the knowledge on various bulk deformation processes and its applications.	**3.1**	Illustrate the different bulk deformation processes.
4.0	To expose knowledge on sheet metal forming processes and special forming processes and to make small sheet metal parts.	**4.1**	Explain the sheet metal forming processes and make simple sheet metal components.
5.0	To learn about the various plastics moulding and forming processes and to make simple plastic part.	**5.1**	Identify the suitable moulding and forming processes of plastics for produce simple plastic parts

UNIT I – METAL CASTING PROCESSES	**(9)**
Sand Casting – Sand Mould – Type of patterns - Pattern Materials – Pattern allowances – Molding sand Properties and testing – Cores –Types and applications – Molding machines – Types and applications– Melting furnaces – Principle of special casting processes- Shell, investment – Ceramic mould – Pressure die casting – low pressure, gravity- Tilt pouring, high pressure die casting- Centrifugal Casting – CO_2 casting –- Defects in Sand casting process-remedies	
UNIT II - METAL JOINING PROCESSES	**(9)**
Fusion welding processes – Oxy fuel welding – Filler and Flux materials-–Arc welding, Electrodes, Coating and specifications – Gas Tungsten arc welding –Gas metal arc welding - Submerged arc welding – Electro slag welding– Plasma arc welding — Resistance welding Processes -Electron beam welding –Laser beam Welding Friction welding – Friction stir welding – Diffusion welding – Thermit Welding, Weld defects – Inspection & remedies – Brazing - soldering – Adhesive bonding.	
UNIT III – BULK DFORMATION PROCESSES	**(9)**
Hot working and cold working of metals – Forging processes – Open, impression and closed die forging – cold forging- Characteristics of the processes – Typical forging operations – rolling of metals – Types of Rolling – Flat strip rolling – shape rolling operations – Defects in rolled parts – Principle of rod and wire Drawing – Tube drawing – Principles of Extrusion – Types – Hot and Cold extrusion. Introduction to shaping operations.	
UNIT IV – SHEET METAL FORMING AND SPECIAL FORMING PROCESSES	**(9)**
Sheet metal characteristics – Typical shearing, bending and drawing operations – Stretch forming operations – Formability of sheet metal – Test methods –special forming processes - Working principle and applications – Hydro forming – Rubber pad forming – Metal spinning – Introduction of Explosive forming, magnetic pulse forming, peen forming, Super plastic forming – Micro forming – Incremental forming.	
UNIT V –MANUFACTURE OF PLASTIC COMPONENTS	**(9)**
Types and characteristics of plastics – Molding of thermoplastics & Thermosetting polymers– working principles and typical applications – injection molding – Plunger and screw machines – Compression molding, Transfer Molding – Typical industrial applications – introduction to blow molding – Rotational molding – Film blowing – Extrusion – Thermoforming – Bonding of Thermoplastics- duff moulding.	
	TOTAL (L:45) : 45 PERIODS

TEXT BOOK:

1. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India,4th Edition, 2013
2. P.N .Rao Manufacturing Technology Volume 1 McGrawhill Education 5th edition, 2018.

REFERENCES:

1. HajraChoudhury S.K, HajraChoundhury A.K and Nirjhar Roy, "Elements of Workshop Technology", Vol. 1, 2017
2. HMT, "Production Technology", "McGraw Hill Education", 2017
3. Sharma.P.C, "A Textbook of Production Technology", S. Chand Publications, 2014
4. S. Gowri P. Hariharan, A.SureshBabu, Manufacturing Technology I, Pearson Education, 2008.
5. Ro y. A. Lindberg, Processes and materials of manufacture, PHI / Pearson education, 2006.
6. Rajput.R.K, "A Textbook of Manufacturing Technology", 2nd ed., Laxmi Publications (P) Ltd, 2016

COs	**POs**												**(PSOs)**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	-	2	-		-	-	-	1	2		2	3	-
2	3	-	2	-		-	3	-	1	2		2	3	-
3	3	-	2			-	-	-	1	2		2	3	-
4	3	-	2		-	-	-	-	1	2		2	3	-
5	3	-	2	-		-	-	-	1	2		2	3	-
CO (W.A)	**3**	**-**	**2**	**-**	**-**	**-**	**3**	**-**	**1**	**2**		**2**	**3**	**-**

22MEC07 ENGINEERING MATERIALS AND METALLURGY

L	T	P	C
3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To develop the knowledge on structure of materials including crystallography, microstructure, defect	1.1	Suggest suitable engineering materials for different application
2.0	To understand the importance of various ferrous materials and phase diagram.	2.1	Infer the composition and properties of ferrous metals and phase diagram
3.0	To apply the suitable heat treatment process to Enhance the property of a material.	3.1	Apply suitable heat treatment process based on material properties
4.0	To know mechanical properties of materials.	4.1	Evaluate the mechanical behavior of materials for different applications
5.0	To give insight in to advanced materials such as polymers, ceramics and composite and their applications.	5.1	Demonstrate the structure-property relationship and allied applications of polymers and ceramics

UNIT I - STRUCTURES OF MATERIALS **(9)**

Materials Science - Simple Crystal Structures - BCC, FCC, HCP Structures - Unit Cell - Defects - Point, Line, Surface, Volume - Slip planes and slip systems - Schmid's rule - Polymorphism and allotropy.

UNIT II - PHASE DIAGRAMS AND PHASE TRANSFORMATION **(9)**

Gibbs's Phase rule - Solidification and Solid Solutions - Equilibrium Diagrams - Classification of Equilibrium Diagrams - Isomorphous System - Eutectic systems, Eutectoid, Peritectic and Peritectoid system - Iron-Iron carbide phase diagram - Phase, Time - Temperature - Transformation (TTT), Continuous Cooling Transformation (CCT) and Martensitic Transformation - Types and applications of Steels and Cast Irons.

UNIT IV - HEAT TREATMENT PROCESS **(9)**

Heat treatment – Overview – Objectives – Annealing and types, normalizing, quenching, austempering and martempering – microstructure changes – Surface hardening processes - Carburizing – nitriding – cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam hardening.

UNIT IV - MECHANICAL PROPERTIES OF MATERIALS **(9)**

Testing of Materials - Classification of tests, Tensile test, Impact test, Hardness test Tension and Torsion test - Stress-strain Curve - Fractures in metals - Ductile Fracture, Brittle Fracture - Methods of protection against fracture - Creep test - stages of creep - Prevention of Creep Fracture

UNIT V –ADVANCED MATERIALS **(9)**

Non Ferrous Metals - Aluminium, Copper, Nickel, Magnesium, Zinc, Lead, Non Ferrous Alloys - Copper alloys, Aluminium alloys - precipitation of hardening, Magnesium alloys and Nickel alloys. Non Metallic Materials - Polymers, Ceramics and Composites - Overview of Nanomaterials.

TOTAL (L:45) : 45 PERIODS

TEXT BOOK:
1. Balasubramaniam R. "Callister's Materials Science and Engineering". 2nd Edition, Wiley India Pvt. Ltd., 2017
REFERENCES:
3. Kenneth G.Budinski and Michael K.Budinski, Engineering Materials Prentice-Hall of India 4. Raghavan.V. Materials Science and Engineering, Prentice Hall of India 5. PremamoyGhosh., "Polymer Science and Technology: Plastics, Rubbers, Blends and Composites". 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011. 6. SinaEbnesajjad. "Handbook of Biopolymers and Biodegradable Plastics: Properties, Processing and Applications", 1st Edition, Elsevier, Amsterdam, Netherlands, 2012. 7. Bolton, W., Engineering materials technology: Butterworth-Heinemann.

Mapping of COs with POs / PSOs														
COs	**POs**												**PSOs**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	-	-	-	-	-	-	3	2	2	2	-
2	3	-	-	-	-	-	-	-	-	3	2	2	2	-
3	3	-	-	-	-	-	-	-	-	3	2	2	2	-
4	3	2	2	-	2	-	-	-	-	3	2	2	2	-
5	3	2	2	-	-	-	-	-	-	3	2	2	2	-
CO (W.A)	**3**	**2**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**3**	**2**	**2**	**2**	**-**

22MEP02 COMPUTER AIDED MACHINE DRAWING

	L	T	P	C
	0	0	4	2

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To instruct the basics of geometric dimensioning and tolerance which is incorporate with machine components.	1.1	Remember to permit dimensional variations in the manufacture of components
2.0	To inculcate the important of tolerances and fit in the assembly of the machine components.	2.1	Apply suitable tolerances to assemble parts and features, to ensure assembly of fit and functionality
3.0	To impart the knowledge of drawing practices for common machine components	**3.1**	Illustrate various machine components through drawings.
4.0	To familiarize in drawing assembly, orthographic and sectional views of various machine components.	**4.1**	Draw the various components/products elements using modeling software.
5.0	To Formulate the detailed drawing of the given component	**5.1**	Imagine and draw the assembled views of machine parts using modeling software.

PART I DRAWING STANDARDS & FITS AND TOLERANCES 12

Code of practice for Engineering Drawing, Welding symbols, riveted joints, keys, and fasteners Limits, Fits– Tolerancing of individual dimensions - basic principles of Geometric Dimensioning &Tolerancing

PART II MODELING AND ASSEMBLY 48

List of Experiment

Creation of 3D modeling, assembly and drafting of Plummer Block

Creation of 3D modeling, assembly and drafting of Connecting Rod

Creation of 3D modeling, assembly and drafting of Universal Coupling

Creation of 3D modeling, assembly and drafting of Knuckle Joint

Creation of 3D modeling, assembly and drafting of Screw Jack

TOTAL:60 PERIODS

Mapping of COs with POs / PSOs														
COs	**POs**												**PSOs**	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	3		3					2		3	3	3
2	3	2	3		3					2		3	3	3
3	3	2	3		3					2		3	3	3
4	3	2	3		3					2		3	3	3
5	3	2	3		3					2		3	3	3
CO (W.A)	**3**	**2**	**3**		**3**					**2**		**3**	**3**	**3**

22MEC09 THERMAL ENGINEERING SYSTEM					
		L	T	P	C
		3	1	0	4
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To enable the students to gain the basic knowledge on working of I.C Engines	1.1	Demonstrate the working principles of I.C Engines and its various components		
2.0	To learn the performance calculations of I.C Engines and the working of auxiliary equipments	2.1	Calculate the performance of I.C Engines		
3.0	To Understand the working of boilers and functions of nozzles	**3.1**	Design the steam nozzles for thermal power plants		
4.0	To Comprehending the various components in thermal power plant and functions of steam turbine	**4.1**	Compute the efficiency of the Rankine cycle and steam turbine		
5.0	To Impart knowledge in the performance of Refrigeration and air-conditioning	**5.1**	Examine the CoP of Refrigeration and describe the working of air conditioning components		

UNIT I - INTERNAL COMBUSTION ENGINES – FUNDAMENTALS AND COMBUSTIONS	**(9+3)**
IC engine – Classification, working, components and their functions. Ideal and actual : Valve and port timing diagrams, p-v diagrams- two stroke & four stroke, and SI & CI engines – comparison. Geometric, operating, and performance comparison of SI and CI engines. Desirable properties and qualities of fuels. Air-fuel ratio calculation – lean and rich mixtures. Combustion in SI & CI Engines – Knocking – phenomena and control	
UNIT II - INTERNAL COMBUSTION ENGINES - PERFORMANCES AND AUXILIARY SYSTEMS	**(9+3)**
Performance and Emission Testing, Performance parameters and calculations. Morse and Heat Balance tests. Multipoint Fuel Injection system and Common rail direct injection systems. Ignition systems – Magneto, Battery and Electronic. Lubrication and Cooling systems. Concepts of Supercharging and Turbo charging – Emission Norms	
UNIT III - STEAM BOILERS AND NOZZLES	**(9+3)**
Classifications – comparison - Fire tube boiler and water tube boiler – simple vertical, Cochran boiler, Locomotive, Babcock and Wilcox boilers – High pressure boiler – Lamont boiler and Loeffler boiler – Steam nozzle – convergent and divergent nozzle - steam flow through nozzles – nozzle efficiency – Metastable expansion of steam in a nozzle	
UNIT IV - STEAM POWER CYCLES AND STEAM TURBINE	**(9+3)**
Steam Power Cycles - Carnot Cycle - Rankine Cycle - Modified Rankine Cycle - Regenerative Cycle - Steam Turbine - Classifications – working - Impulse and reaction turbine – Compounding – velocity diagram of impulse turbine	
UNIT V - REFRIGERATION AND AIR CONDITIONING	**(9+3)**
Fundamentals of refrigeration - COP - simple vapour compression system – Effect of super heating, Effect of sub cooling - working principle of vapour absorption system - refrigerants, classification, properties - air conditioning systems- summer, winter, year round air conditioning - central system	
TOTAL (L:45+T:15) : 60 PERIODS	

TEXT BOOK:

1. Rajput.R.K, "Thermal Engineering", 11thEdition., Laxmi Publications Ltd, 2020
2. Ganesan V, Internal Combustion Engines, 4th Edition, McGraw-Hill companies, 2017

REFERENCES:

1. Ba llaney. P.L "Thermal Engineering", 25th Edition, Khanna Publishers, 2017.
2. Manohar Prasad, "Refrigeration and Air Conditioning", 3rd ed., New Age International publications, 2021
3. Arora C P, "Refrigeration and Air Conditioning",4th Edition., Tata McGraw - Hill Education, 2021
4. Rudramoorthy.R, "Thermal Engineering", Tata McGraw-Hill, New Delhi, 2017

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3								3		3		
2	3	3								3		3		
3	3	3	3							3		3	2	
4	3	3	3							3		3	2	
5	3	3	3							3		3	2	
CO (W.A)	**3**	**3**	**3**							**3**		**3**	**2**	

22MEC10 SUBTRACTIVE MANUFACTURING PROCESSES				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To study the concepts and basic mechanics of metal cutting and the factors affecting machinability	**1.1**	Apply the mechanism of metal removal process and to identify the factors involved in improving machinability.
2.0	To learn working of basic and advanced turning machines.	**2.1**	Describe the constructional and operational features of centre lathe and other special purpose lathes.
3.0	To apply the working of machine namely shaping, planing, slotting and different drilling machines	**3.1**	Understand the constructional and operational features of reciprocating machine tools.
4.0	To study the basic concepts of CNC of machine tools and constructional features of CNC.	**4.1**	Apply the constructional features and working principles of CNC machine tools.
5.0	To learn the basics of CNC programming concepts to develop the part programme for Machine centre and turning centre	**5.1**	Demonstrate the Program CNC machine tools through planning, writing codes and setting up CNC machine tools to manufacture a given component.

UNIT I - THEORY OF METAL CUTTING	**(9)**
Mechanics of chip formation, forces in machining, Types of chip, cutting tools – single point cutting tool nomenclature, orthogonal and oblique metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability.	
UNIT II – TURNING MACHINES	**(9)**
Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, surface roughness in turning, machining time and power estimation. Special lathes - Capstan and turret lathes- tool layout – automatic lathes: semi-automatic – single spindle: Swiss type, automatic screw type – multi spindle	
UNIT III – RECIPROCATING MACHINE TOOLS	**(9)**
Reciprocating machine tools: shaper, planer, slotter: Types and operations- Hole making: Drilling, reaming, boring, tapping, type of milling operations-attachments- types of milling cutters– machining time calculation - Gear cutting, gear hobbing and gear shaping – gear finishing methods Abrasive processes: grinding wheel – specifications and selection, types of grinding process – cylindrical grinding, surface grinding, centreless grinding, internal grinding - micro finishing methods .	
UNIT IV – CNC MACHINES	**(9)**
Computer Numerical Control (CNC) machine tools, constructional details, special features – Drives, Recirculating ball screws, tool changers; CNC Control systems – Open/closed, point-to-point/continuous - Turning and machining centres – Work holding methods in Turning and machining centres, Coolant systems, Safety features.	
UNIT V – PROGRAMMING OF CNC MACHINE TOOLS	**(9)**
Coordinates, axis and motion, Absolute vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers – Fixed cycles, Loops and subroutines, Setting up a CNC machine for machining.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India, 7th Edition, 2018.
2. Richard R Kibbe, John E Neely, Roland O Meyer and Warren T White, "Machine Tool Practices", Prentice Hall of India, New Delhi, 10th Revised edition, 2014

REFERENCES:

1. HajraChoudhury S.K, HajraChoundhury A.K and Nirjhar Roy, "Elements of Workshop Technology", Vol. II, Media Promoters and Publishers Pvt Ltd., 2017
2. Jain R.K. and Gupta S.C., "Production Technology", Khanna Publishers, New Delhi, 2014
3. Rao P.N, "Manufacturing Technology - Metal Cutting and Machine Tools", Vol. I & II Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2017
4. Sharma P.C., "A Textbook of Production Technology", S.Chand and Company Ltd., 2014
5. Peter Smid, CNC Programming Handbook, Industrial Press Inc.; Third edition, 2007.

Mapping of COs with POs / PSOs

COs	POs												PSOs	
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1	3	3	3	-	1	-	-	-	-	3	-	2	3	-
2	3	3	3	-	1	-	-	-	-	3	-	2	3	-
3	3	3	3	-	1	-	-	-	-	3	-	2	3	-
4	3	3	3	-	1	3	-	-	-	3	-	2	3	2
5	3	3	3	-	1	3	-	-	-	3	-	2	3	2
CO (W.A)	**3**	**3**	**3**	**-**	**1**	**3**	**-**	**-**	**-**	**3**	**-**	**2**	**3**	**2**

22MEC11 STRENGTH OF MATERIALS					
		L	T	P	C
		3	0	2	4
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			
1.0	To provide knowledge about stress distribution and strain in regular and composite structures subjected to axial loads	**1.1**	Determine stress and strain in regular and composite structures subjected to axial load and thermal load.		
2.0	To familiarize about bi-axial stress systems and stresses in thin cylinders	**2.1**	Evaluate the stresses in bi-axial stress systems and thin cylinders		
3.0	To give input on shear force, bending moment diagrams and evaluate the bending stress in different beams under transverse loading	**3.1**	Assess the shear force, bending moment and bending stresses in beams under transverse loading		
4.0	To impart knowledge on finding slope and deflection of beams and buckling of columns for different boundary conditions	**4.1**	Evaluate the slope and deflection of beams and buckling loads of columns under different boundary conditions		
5.0	To provide awareness on stresses on shafts and helical springs based on theory of torsion	**5.1**	Apply torsion equation in design of circular shafts and helical springs		

UNIT I: STRESSES AND STRAIN	**9**
Introduction to material properties, Stress-strain curve for ductile and brittle materials, Hooke's law, Stresses and strain due to axial force in Stepped and Composite bars, Stresses due to thermal effect in composite bars, Factor of safety, Poisson-ratio, Volumetric strain, Elastic constants and their relationship	
UNIT II: BI-AXIAL STRESS SYSTEM	**9**
State of stresses at a point, Normal and shear stresses on inclined planes, Principal planes and Principal stresses, Plane of maximum shear stress, Mohr's circle for bi-axial stress with shear stress. Hoop and longitudinal stresses in thin cylindrical vessels, Maximum Shear stress, Changes in dimensions and volume.	
UNIT III: SHEAR FORCE, BENDING MOMENT AND STRESSES IN BEAMS	**9**
Types of beams, supports and Loads, Shear force and Bending Moment diagram of Cantilever, simply supported and overhanging beams, Point of contra flexure. Theory of Simple Bending, Bending stress.	
UNIT IV: DEFLECTION OF BEAMS AND COLUMNS	**9**
Slope and Deflection of cantilever and simply supported beams by Double integration method and Macaulay's method. Types of Columns, Equivalent length, Euler and Rankine's formulae, Slenderness ratio	
UNIT V: TORSION IN SHAFT AND HELICAL SPRING	**9**
Torsion equation - stresses and deformations in circular solid, circular hollow and stepped shafts - Closed coil helical spring-stresses and deflection under axial load.	

LIST OF EXPERIMENTS

1. Study of Stress / Strain curves for various materials
2. Tension test on steel rod
3. Double shear test in UTM
4. Rockwell Hardness test
5. Brinell Hardness Test
6. Izod impact test
7. Deflection test on Steel beam
8. Deflection test on Wooden beam
9. Compression test on Bricks
10. Compression test on helical spring

TOTAL (L:45 + P:30): 75 PERIODS

TEXT BOOK:

1. Bansal.R.K, "A textbook of Strength of Materials: (Mechanics of Solids) SI Units", 6th ed., Laxmi Publications, 2017
2. Ferdinand Beer Jr., E. Russell Johnston Jr., John T. DeWolf and David F. Mazurek, "Mechanics of Materials", 7th ed., McGraw Hill, 2011

REFERENCES:

1. S.S. Rattan, Strength of Materials, McGraw Hill Education (India) Private Limited, Chennai, Third Edition, 2017
2. S.S. Bhavikatti, Strength of Materials, Vikas Publishing House, New Delhi, Fourth edition, 2013
3. Egor P. Popov, Engineering Mechanics of Solids, Pearson India Education Services Pvt Ltd, New Delhi, 2015
4. Ramamrutham.S and Narayanan.R, "Strength of Materials", DhanpatRai Publications, 2017
5. Rajput R.K, "Strength of Materials", 6th ed., S.Chand and Company Ltd, 2015

Mapping of COs with POs / PSOs

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	1						3	3		2	2	
2	3	3	2						3	3		2	2	
3	3	3	2						3	3		2	2	
4	3	3	2						3	3		2	2	
5	3	3	2						3	3		2	2	
CO (W.A)	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**2**	**2**	**-**

22MEC12 - THEORY OF MACHINES					
		L	T	P	C
		3	0	2	4
PRE REQUISITE : 22MEC03-Engineering Mechanics					
Course Objectives		**Course Outcomes**			
		At the end of the course, the students would be able to			
1.0	To know the basic components and velocity / acceleration analysis of mechanisms.	**1.1**	Demonstrate the working of various mechanisms and determine the velocity and acceleration of mechanisms.		
2.0	To understand the basic concepts of toothed gearing and kinematics of gear trains.	**2.1**	Describe the concepts and applications of kinematics of gears and gear trains.		
3.0	To acquire knowledge on cam mechanisms for specified output motions and the effects of friction in machine elements.	**3.1**	Explain the concepts of cam follower system and examine the friction concepts in various engineering applications.		
4.0	To introduce the concepts of static and dynamic force analysis in mechanisms and reciprocating engines.	**4.1**	Analyze the static and dynamic forces in mechanisms and reciprocating engines.		
5.0	To learn the balancing concepts of rotating and reciprocating masses and the various types of vibrations	**5.1**	Apply the balancing concepts in reciprocating and rotating masses to solve problems; and Compute the frequency of various types of vibrations.		

UNIT - I KINEMATICS OF MECHANISMS AND ANALYSIS	**(9)**
Mechanisms – Terminology and definitions – Degree freedom of simple mechanism – Grashof's Law - Kinematic Inversions of Four bar chain, Single slider and Double slider crank chains –kinematics Analysis in slider crank mechanism - Velocity and Acceleration- Analytical method.	
UNIT – II GEARS AND GEAR TRAINS	**(9)**
Spur gear – law of toothed gearing – involute gearing – Interchangeable gears – Gear tooth action interference and undercutting – nonstandard teeth – gear trains – parallel axis gears trains – epicyclic gear trains – automotive transmission gear trains	
UNIT- III KINEMATICS OF CAMS AND FRICTION DRIVES	**(9)**
Classifications of Cams and Followers - Displacement diagrams for uniform velocity, simple harmonic motion, constant acceleration and deceleration, cycloidal motions - Graphical layout of radial cam profile with in-line knife edge follower- tangent cam and circular arc cam. Friction- Surface contacts – Sliding and Rolling friction- Friction drives – Plate clutches and belt drive.	
UNIT – IV FORCE ANALYSIS	**(9)**
Static force analysis - static equilibrium conditions - free body diagrams - static Equilibrium conditions – Two, Three and four members - graphical force analysis without friction for four bar mechanism and slider crank mechanism - Dynamic force analysis in Reciprocating Engines –D'Alembert's principle - analytical method of engine force analysis without inertia.	
UNIT – V BALANCING AND VIBRATION	**(9)**
Static and Dynamic balancing - Balancing of rotating masses – balancing of reciprocating masses - tractive force, swaying couple, hammer blow – vibration- Free longitudinal and transverse vibrations – natural Frequency – Damped Vibration – critical speed of simple shaft –torsional vibrations on single and two rotor systems.	

LIST OF EXPERIMENTS

1. Determination of transmission angle and toggle position of four bar mechanisms.
2. Determination of ratio of time of cutting stroke to return stroke and length of stroke of quick return mechanism.
3. Experimental study of Gears, Gear trains and Differential unit.
4. Determination of moment of inertia of an object by oscillation method.
5. Determination of jump speed of the cam.
6. Balancing of rotating mass of the shaft.
7. Deflection of fixed –free cantilever beam.
8. Determination of natural frequency of vibration of the spring mass system.
9. Determination of whirling speed of shaft.
10. Determination of natural frequency of the free torsional vibration of the single rotor system.

TOTAL (L:45 + P:30): 75 PERIODS

TEXT BOOK:

1. John J. Uicker, Jr., Gordon R. Pennock and Joseph E. Shigley, "Theory of Machines and Mechanisms - SI Edition", 4th ed., Oxford University Press, 2017
2. Khurmi.R.S and Gupta.J.K, "Theory of Machines", 15th ed., S.Chand & Company Pvt. Ltd., 2017

REFERENCES:

1. Rattan.S.S, "Theory of Machines", 5th ed., McGraw Hill Education India Private Limited, 2019
2. Ambekar A.G, "Mechanism and Machine Theory",1st ed., Prentice Hall of India, 2013
3. Bansal.R.K and Brar.J.S, "Theory of Machines", 5th ed., Laxmi Publications, Revised 2016
4. Ghosh A. and Mallick A.K., "Theory of Mechanisms and Machines", East-West Publications, 2008
5. Kenneth J Waldron and Gary L Kinzel, "Kinematics, Dynamics, and Design of Machinery", 3rd ed., Wiley India Pvt Ltd, 2016

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	-	-	-	-	2	2	-	3	2	-
2	3	3	3	3	-	-	-	-	2	2	-	3	2	-
3	3	3	3	3	-	-	-	-	2	2	-	3	2	-
4	3	3	3	2	-	-	-	-	2	2	-	3	2	-
5	3	3	3	2	-	-	-	-	2	2	-	3	2	-
CO (WA)	**3**	**3**	**3**	**2.4**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**3**	**2**	**-**

22EDA02 CONCEPTS OF ENGINEERING DESIGN					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

Course Objectives		Course Outcomes	
1.0	To understand the fundamentals of design process for products	**1.1**	Apply the design concepts in various industrial products based on customer requirements.
2.0	To impart the importance of design in today's context of global competition, environmental awareness and customer oriented market.	**2.1**	Utilize the statistical tools in monitoring the performance of products.
3.0	To understand the various design methods of engineering design	**3.1**	Be familiar with the design concepts to improve the reliability and productivity.
4.0	To understand the selection of proper materials	**4.1**	Apply the material selection process and design for manufacture.
5.0	To impart the basic concepts and various aspects of design using simple examples and case studies.	**5.1**	Gain knowledge about the failure mode effect analysis and green design process.

UNIT I : DESIGN FUNDAMENTALS	**(9)**
Importance of design - Design process - Considerations of good design - Morphology of design - Organization for design – Designing to codes and standards - Product and process cycles - Technological innovation.	
UNIT II : CUSTOMER ORIENTED DESIGN	**(9)**
Identification of customer needs - Customer requirements - Bench marking quality function deployment - Product design specifications - Human factors in design - Ergonomics and aesthetics - Contracts - Product liability - Protecting intellectual property - Legal and ethical domains -Codes of ethics -Ethical conflicts.	
UNIT III : DESIGN METHODS	**(9)**
Creativity and problem solving - Creative thinking methods - Theory of inventive problem solving (TRIZ) - Decision making - Embodiment design - Product architecture - Configuration design - Parametric design - Role of models in design - Rapid prototyping - Finite element analysis - Optimization.	
UNIT IV : MATERIAL SELECTION PROCESSING AND DESIGN	**(9)**
Material selection process - Economics -Weighted property index - Classification of manufacturing process - Design for manufacture - Design for assembly - Designing for castings, Forging, Metal Forming, Machining and Welding - Residual stresses.	
UNIT V : PROBABILITY CONCEPTS IN DESIGN & GREEN DESIGN PROCESS	**(9)**
Probability - Distributions - Test of hypothesis - Design of experiments - Reliability theory - Design for reliability - Robust design - Failure mode effect analysis. Design for environment - Green design process: Material life cycle, embodied energy, carbon footprint, green design in industry, sustainability.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Dieter George E., "Engineering Design - A Materials and Processing Approach", 4th ed., Tata McGraw Hill, 2013.
2. Pahl, G, and Beitz, W., "Engineering Design", 3rd ed., Springer – Verlag, NY. 2007.
3. Robert C Juvinall, "Fundamentals of Machine Component Design", Wiley, 2011.
4. Suh, N.P., "The Principles of Design", Oxford University Press, NY.1990.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	1	3	2	1	2	1	2	1
2	2	1	2	1	2	3	3	2
3	2	2	2	2	1	1	3	1
4	1	2	3	2	2	1	2	2
5	1	1	2	1	1	1	3	2
CO (W.A)	**1.4**	**1.8**	**2.2**	**1.4**	**1.6**	**1.4**	**2.6**	**1.6**

22EDB01 MECHANICAL VIBRATIONS AND ACOUSTICS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To understand the basic concepts of free and forced vibration with damped and undamped systems	**1.1**	able to analyze response of a SDOF system, damped or undamped, subjected to force excitations
2.0	To determine the natural frequencies and mounting of vibration absorbers in the two degree freedom systems	**2.1**	Identify the solutions for Machine vibration problems with two degree freedom systems using mathematical or numerical analysis.
3.0	To structure the stiffness matrix and calculate the natural frequencies of Multi Degree Freedom System and Continuous System.	**3.1**	Able to write the differential equations of motion for Multi Degree of Freedom and obtain the Eigen-values and mode shapes of natural vibrations
4.0	To recognize the control technique of vibration in machines.	**4.1**	Categorize the causes for vibrations in engineering systems using vibration control and analysis techniques
5.0	To know the terminologies in acoustics and acoustic wave transmission	**5.1**	Illustrate the basics of psychoacoustics, Equal loudness, scale, loudness, pitch loudness and noise.

UNIT I – FUNDAMENTALS AND SIGNLE DEGREE OF FREEDOM	**(9)**
Introduction -Sources Of Vibration – Methods of Vibration Analysis – Types of Vibration - Review Of Single Degree of Freedom Systems - Free vibrations, free damped vibrations, and forced vibrations with and without damping – Vibration Measuring Instruments vibrometers and accelerometer - Response To Arbitrary and non-harmonic Excitations – Transient Vibration – Impulse loads- Critical Speed Of Shaft-Rotor systems.	
UNIT II - TWO DEGREE FREEDOM SYSTEM	**(9)**
Introduction - Free Vibration of Undamped and Damped – Forced Harmonic Vibration – Semi definite System - Coordinate Couplings – Vibration absorber – Torsional vibration absorber – Centrifugal pendulum absorber – Untuned vibration dampers	
UNIT III - MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM	**(9)**
Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method – Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method - Continuous System – Vibration of String, Shafts and Beams.	
UNIT IV – VIBRATION ANALYSIS AND CONTROL	**(9)**
Vibration Analysis Overview - Vibration Measuring Instruments - Selection of Sensors - Accelerometer Mountings. -Vibration Exciters - Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments - Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods - Dynamic Vibration Absorber - Static and Dynamic Balancing machines – Field balancing.	

UNIT V - ACOUSTICS	(9)
Psychoacoustics, Speech, mechanism of hearing, thresholds of the ear – sound intensity and frequency, loudness, equal loudness levels, loudness, pitch and timbre, beats, masking by pure tones, masking by noise.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. V.P. Singh, Raveesh Pratap, "Mechanical Vibrations", Dhanpat Rai Publications, New Delhi, 2015
2. Singiresu S Rao "Mechanical Vibrations", Prentice Hall, 2016.
3. Ramamurti.V,"MechanicalVibrationPracticewithBasicTheory",NarosaPublishingHouse, 2010
4. Lawrence E. Kinsler and Austin R.Frey, "Fundamentals of acoustics", Wiley Eastern Ltd., 1987.
5. Michael Rettinger, "Acoustic Design and Noise Control", Vol. I & II. , Chemical Publishing Co., New York, 1977.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) /Programme SpecificOutcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	1	3	3	2	2	1	3	3
2	2	3	2	3	2	2	3	3
3	3	3	2	3	2	2	3	3
4	1	2	1	2	1	2	2	2
5	1	1	1	2	3	1	2	2
CO (W.A)	**1.6**	**2.4**	**1.8**	**2.4**	**2**	**1.6**	**2.6**	**2.6**

22EDB02 FAILURE ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To impart knowledge about various modes of failure this leads to materials and design.	**1.1**	Demonstrate the various modes of failure and material behavior in fracture loading.
2.0	To learn about large variety of fracture mechanisms and fracture modes associated with failure.	**2.1**	Examine the fracture mechanisms and fracture, creep, fatigue, corrosion and wear failures.
3.0	To provide an exposure to the students on statistical nature of fatigue and fatigue tests	**3.1**	Implement of fatigue analysis principles in innovative applications.
4.0	To provide fundamental knowledge of corrosion and environmentally-assisted cracking.	**4.1**	Demonstrate the corrosion and wear failure analysis.
5.0	To study about industrial application of failure analysis tools.	**5.1**	Demonstrate the failure analysis tools.

UNIT I : MATERIALS AND DESIGN PROCESS (9)

Factors affecting the behavior of materials in components, effect of component geometry and shape factors, design for static strength, stiffness, designing with high strength and low toughness materials, material selection process, introduction to stress, two dimensional and three-dimensional state of stress, Mohr's circle two and three dimensions, hydrostatic stress, von-Mises, maximum shear stress (Tresca), octahedral shear stress.

UNIT II : FRACTURE MECHANICS (9)

Ductile fracture, brittle fracture, cleavage-fractography, ductile to brittle transition, factors affecting ductile to brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach, time dependent crack growth and damage - Linear Elastic Fracture Mechanics: Griffiththeory, energy release rate, Instability and R-curve, stress analysis of cracks-stress intensity factor, Crack growth instability analysis.

UNIT III :FATIGUE (9)

Statistical nature of fatigue, signal-noise curve, low cycle fatigue, strain life equations, structural feature of fatigue, fatigue crack propagation, effect of stress concentration, size, surface properties, metallurgical variables on fatigue, case studies, designing against fatigue, detail design, improvements after failure and service, fatigue of bolts, welded and adhesive joints. Fatigue Tests-Purpose, specimen, fatigue test procedures, evaluation of fatigue test results, crack growth measurement. Creep, stress rupture, elevated temperature fatigue, super plasticity.

UNIT IV : CORROSION AND WEAR FAILURES (9)

Types of corrosion, Factors influencing corrosion failures, analysis of corrosion failures, stress corrosion cracking - sources, characteristics of stress corrosion cracking, procedure of analyzing stress corrosion cracking, various types of hydrogen damage failures, corrective and preventive action. Types of wear, lubricated and non – lubricated wear, wear on different materials, different methods of wear measurement. Role of friction on wear, analysis of wear failures, wear tests -ferrography

UNIT V : FAILURE ANALYSIS TOOLS (9)

Reliability concept and hazard function, application of Poisson, exponential and Weibull distribution for reliability, bathtub curve, parallel and series system, failure mode effect analysis - definition-Design, types, process, industrial case studies / Projects.

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Yiannis Papadopoulos, Engineering failure analysis and design optimization with HiPHOPS" Engineering Failure Analysis, Volume 18, Issue 2, pp 590–608, March 2011.
2. F. Rui, Martins, Failure analysis of bilge keels and its design improvement, Engineering Failure Analysis, Volume 27, pp 232–249, January 2013.
3. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, CRC Press, 2005.
4. F.Michael and Ashby, Material Selection in Mechanical Design, Butterworth Heinemann, 2004.
5. ASM Metals Handbook, Failure Analysis and Prevention, ASM Metals Park, Ohio, USA, Vol.10, 2002.
6. J.E. Shigley and Mische, Mechanical Engineering Design, McGraw Hill, 2000.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1			1			1		
2	2	2	3	3	1	2		2
3	2	2	3	3	1	2		2
4	2	2	3	3	1	2		2
5			1	1		1		
CO (W.A)	**2**	**2**	**2.2**	**2.5**	**1**	**1.6**		**2**

22EDB03 COMPUTER APPLICATIONS IN DESIGN				
	L	T	P	C
	3	0	0	3

PREREQUISITE :

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To develop the modeling skills using computer graphic techniques.	1.1	Demonstrate computer graphic techniques
2.0	To impart knowledge on CAD software and data exchange standards.	2.1	Using CAD software to exchange standards data
3.0	To study the applications of NURBS and solid modeling.	3.1	Use of CAD software transfer of product data in various software.
4.0	To gain knowledge on visual realism and computer animation.	4.1	Describe the types NURBS and solid modeling
5.0	To provide knowledge on assembly modeling and tolerance analysis.	5.1	Demonstrate the knowledge of assembly modeling and tolerance analysis

UNIT I : INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS	(9)
Output primitives (points, lines, curves etc.) 2D & 3D transformation (Translation, scaling, rotations) windowing - view ports - clipping transformation Open GL Data Exchange standards- IGES, STEP etc. - Communication standards.	
UNIT II : CURVES AND SURFACE MODELING	**(9)**
Representation of curves - Bezier curves- cubic spline curve - B-Spline curves - Rational curves - Curve manipulations Representation of surface modeling techniques - Analytical surfaces : Plane surface, ruled surface, surface of revolution and tabulated cylinder - synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface - surface manipulation.	
UNIT III : NURBS AND SOLID MODELING	**(9)**
NURBS - Basics - curves, lines, arcs, circle and bi linear surface Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations constructive solid geometry comparison of representations - user inter face for solid modeling.	
UNIT IV : VISUAL REALISM	**(9)**
Hidden Line - Surface-solid removal algorithms shading - coloring. Introduction to parametric and variational geometry based software sand the in principles creation of prismatic and lofted parts using the sepackages.	
UNIT V : ASSEMBLY OF PARTS	**(9)**
Assembly modeling - interferences of positions and orientation - tolerances analysis - mass property calculations- mechanism simulation	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Ibrahim Zeid, "Mastering CAD/CAM", 2nd ed., McGraw Hill, International Edition, 2006.
2. Donald Hearn, M. Pauline Baker, "Computer Graphics", 4th ed., Prentice Hall, Inc., 2010.
3. William M Neumann, Robert F. Sproul, "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. P.Radhakrishnan, C.P.Kothandaraman, "Computer Graphics and Design", Dhanpat Rai and Sons,1999.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	3	1	1	3	-	3	3	1
2	3	1	1	3	-	3	3	1
3	3	1	1	3	-	3	3	1
4	3	1	1	3	-	3	3	1
5	3	1	1	3	-	3	3	1
CO (W.A)	**3**	**1**	**1**	**3**	**-**	**3**	**3**	**1**

22EDB05 ADVANCED FINITE ELEMENT ANALYSIS

L	T	P	C
3	0	0	3

PREREQUISITE :22EDA01

	Course Objectives		Course Outcomes
1.0	To understand the basic principles of the finite element analysis techniques and enhancing the ability to apply the tools of the analysis for solving practical problems arising in Engineering design.	1.1	Apply finite elements technique in engineering problem solving for various applications.
2.0	To create expertise in basic elements, one and two dimensional problems.	2.1	Derive finite element equation and to solve the real time 1D and 2D structural and thermal problems.
3.0	To create expertise in basic elements of Isoperimetric elements problems.	3.1	Solve and analysis the engineering problems using isoparametric and parametric elements.
4.0	To provide knowledge on structural dynamic analysis of bar and beam element	4.1	Estimate the solve structural dynamic analysis
5.0	To study the non-linear problems and error estimates of FEM	5.1	Create nonlinear problems and error method

UNIT I : ONE-DIMENSIONAL APPLICATIONS	**(9)**
Basic concept of FEM - Weighted residual methods - Variational formulation of B.V.P - Ritz method - Finite element modeling - Element equations - Linear and quadratic shape functions - Bar and beam elements - Bars and beams of arbitrary orientation - Applications to structural heat transfer problems.	
UNIT II : TWO-DIMENSIONAL APPLICATIONS	**(9)**
Poisson equation - Laplace equation - Weak form - Element matrices for triangular and rectangular elements - Evaluation of integrals - Applications – Conduction- and convection heat transfer - Theory of elasticity - Plane strain - Plane stress - Axi-symmetric problems - Principle of virtual displacement.	
UNIT III : ISOPARAMETRIC ELEMENTS	**(9)**
Natural Co-ordinate Systems - Lagrangian Interpolation Polynomials - Isoparametric elements - Quadrilateral elements formulation - Jacobian matrix -Triangular elements - Rectangular elements - Serendipity elements – Numerical Integration - Gauss quadrature - Illustrative Examples.	
UNIT IV : STRUCTURAL DYNAMIC ANALYSIS	**(9)**
Dynamic equations - Consistent and lumped mass matrices - 1D bar element - Formulation of element stiffness, mass and force matrices - Example problems. Natural frequencies - 1D beam element - Formulation of element stiffness, mass matrices.	
UNIT V : NON-LINEAR PROBLEMS AND ERROR ESTIMATES	**(9)**
Introduction - Material non-linearity - Elasto Plasticity - Plasticity - Visco plasticity - Geometric non-linearity - Large displacement - Error norms and convergence rates - H-refinement with adaptivity - adaptive refinement.	
TOTAL (L : 45) :45 PERIODS	

TEXT BOOK:

1. Reddy J.N., "An Introduction to the Finite Element Method", 4rd ed., McGraw Hill, International Edition, 2018.
2. Logan D.L, "A First Course in the Finite Element Method", 6th ed.,Thomson Learning, 2018.

REFERENCES:

1. Cook, Robert Davis et al, "Concepts and Applications of Finite Element Analysis", 4th ed., Wiley, John & Sons, 2007.
2. Chandrupatla, T. R and Belegundu, A.D., "Introduction to Finite Elements in Engineering", 4th ed., Pearson Education, New Delhi, 2018.
3. Rao Singiresu S. "The Finite Element Method in Engineering". 6th Edition, Butterworth-Heinemann, USA, 2017.
4. Bhavikatti SS, "Finite Element Analysis", New Age International Publishers, 2015.
5. Zienkiewicz, O.C. and Taylor, R.L., "The Finite Element Method", 7th ed., McGraw Hill International Edition, Physics Services, 2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	1	3	-	-	3	-
2	3	-	1	3	-	-	3	-
3	3	-	1	3	-	-	3	-
4	3	-	1	3	-	-	3	-
5	3	-	1	3	-	-	3	-
CO (W.A)	3	-	-	3	-	-	3	-

22EDB06 MECHANISMS DESIGN AND SIMULATION

L	T	P	C
3	0	0	3

PRE REQUISITE : Nil

	Course Objectives		Course Outcomes
1.0	To learn the fundamentals of kinematics and various mechanisms.	**1.1**	Familiarize with the fundamentals of kinematics and mechanisms.
2.0	To study the complex mechanisms to determine velocity and acceleration of output links.	**2.1**	Determine velocity and acceleration of complex mechanisms.
3.0	To study the path curvature and coupler curves of mechanisms.	**3.1**	Create the path curvature and coupler curves of mechanisms.
4.0	To study the synthesis of mechanisms.	**4.1**	Synthesize the planar mechanisms.
5.0	To learn the design of six bar coupler driven mechanisms and cam mechanisms and to study Simulation Software packages.	**5.1**	Design the six bar coupler driven mechanisms and cam mechanisms.

UNIT I - INTRODUCTION **(9)**

Review of fundamentals of kinematics - classifications of mechanisms-components of mechanisms - mobility analysis - formation of one D.O.F., Compliant mechanisms - Equivalent mechanisms - Basic kinematic structures of serial and parallel robot manipulators

UNIT II - KINEMATIC ANALYSIS **(9)**

Analytical methods for velocity and acceleration Analysis - four bar linkage jerk analysis. Velocity analysis of Plane complex mechanisms using graphical method - Spatial RSSR mechanism - Denavit-Hartenberg Parameters.

UNIT III - PATH CURVATURE THEORY AND COUPLER CURVE **(9)**

Fixed and moving centrodes, inflection points and inflection circle. Hartmann's construction - Euler Savary equation, graphical constructions - Bobbilier constructions - Cubic of stationary curvature. Four bar coupler curve - cusp - crunode - coupler driven six - bar mechanisms - straight line generators.

UNIT IV - SYNTHESIS OF FOUR BAR MECHANISMS **(9)**

Type synthesis - Number synthesis - Dimensional synthesis - function generation, path generation, motion generation. Associated Linkage Concept. Graphical methods- Inversion technique - point position reduction - two, three and four position synthesis of four-bar mechanisms. Analytical methods - Bloch method and Freudenstein's Equation, Mechanism defects.

UNIT V -SYNTHESIS OF COUPLER CURVE BASED MECHANISMS & CAM MECHANISMS **(9)**

Cognate Linkgages - parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell - double stroke. Geared five bar mechanism-multi-dwell. Cam mechanisms- determination of optimum size of cams. Unbalance, Spring surge and Wind up - Study and use of Mechanism using Simulation Software packages.

**** Term Project must be submitted at end of the Semester**

TOTAL (L:45) : 45 PERIODS

TEXT BOOK:

1. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press. 2017

REFERENCES:

1. Robert L.Norton, "Design of Machinery", Tata McGraw Hill, 2012
2. Sandor G.N. and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Volume II Prentice Hall, 1984.
3. Amitabh A Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 2008.
4. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2016.
5. Jingshan Zhao Associate Pr, Zhijing Feng, "Advanced Theory of Constraint and Motion Analysis for Robot Mechanisms", Academic Press, 2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	1	-	1	1	1	-	1	1
2	1	-	2	3	1	-	2	1
3	1	-	2	3	1	-	2	1
4	1	-	2	3	1	-	2	1
5	1	-	2	3	1	-	2	1
CO (W.A)	1	-	1.8	2.6	1	-	1.8	1

22EDB07 INTEGRATED MECHANICAL DESIGN *(Use of Approved Data Book is Permitted)*					
		L	**T**	**P**	**C**
		3	**0**	**0**	**3**
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To know the integrated design procedure of different machine elements for mechanical applications.	**1.1**	Apply concepts of design of shafts to obtain solutions to real time engineering problems		
2.0	To ensure that the student has thorough conceptual understanding of gear and gear boxes	**2.1**	Identify the gear tooth failure modes and design of gears		
3.0	To study design concepts of dynamics and thermal aspects of brakes and clutches	**3.1**	Integrated design of brakes and clutches for machine tools		
4.0	To study the design of systems consisting of machine elements	**4.1**	Categorize the engineering applications of Integrated design of machine elements		
5.0	To study the design of systems consisting of transmission systems	**5.1**	Apply the concepts of integrated design in transmission systems		

UNIT I : FUNDAMENTALS AND DESIGN OF SHAFTS	**(9)**
Phases of design - Standardization and interchange ability of machine elements - Process and Function Tolerances - Individual and group tolerances - Selection of fits for different design situations - Design for assembly and modular constructions - Concepts of integration - BIS, ISO,DIN, BS, ASTM Standards. Oblique stresses - Transformation Matrix - Principal stresses - Maximum shear stress - Theories of Failure - Ductile vs. brittle component design - Analysis and Design of shafts for different applications - integrated design of shaft, bearing and casing - Design for rigidity	
UNIT II : DESIGN OF GEARS AND GEAR BOXES	**(9)**
Principles of gear tooth action - Gear correction - Gear tooth failure modes - Stresses and loads - Component design of spur, helical, bevel and worm gears - Design for sub assembly - Integrated design of speed reducers and multi-speed gear boxes - application of software packages.	
UNIT III : BRAKES & CLUTCHES	**(9)**
Dynamics and thermal aspects of brakes and clutches - Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipments.	
UNIT IV: INTEGRATED DESIGN OF MACHINE ELEMENTS	**(9)**
Integrated Design of systems consisting of shaft, bearings, springs - Design of Elevators, Escalators	
UNIT V: INTEGRATED DESIGN OF TRANSMISSION SYSTEMS	**(9)**
Integrated Design of systems consisting of belt, rope, chain, pulleys, gears, gear boxes, valve gear mechanisms	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:
1. Norton L. R., "Machine Design - An Integrated Approach" Pearson Education, 2019
REFERENCES:
1. Rajamani, Rajesh. Vehicle dynamics and control. Springer Science & Business Media, 2011. 2. Newcomb, T.P. and Spur, R.T., "Automobile Brakes and Braking Systems", Chapman and Hall, 2nd ed., 1975. 3. Maitra G.M., "Hand Book of Gear Design", Tata McGraw Hill, 1985. 4. Shigley, J.E., "Mechanical Engineering Design", McGraw Hill, 1986. 5. Prasad. L. V., "Machine Design", Tata McGraw Hill, New Delhi, 1992. 6. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	-	-	3	-	1	1	1
2	3	-	-	3	-	1	1	1
3	3	-	-	3	-	1	1	1
4	3	-	-	3	-	1	1	1
5	3	-	-	3	-	1	1	1
CO (W.A)	**3**	**-**	**-**	**3**		**1**	**1**	**1**

22EDP02 ANALYSIS AND SIMULATION LABORATORY				
	L	T	P	C
	0	0	4	2

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To impart hands-on training with ANSYS software for solving practical problems arising in engineering design	**1.1**	Compute the engineering problem using a simulation model and find out the solutions
2.0	To simulate the real time problems by using these software and also to understand the application of analysis packages	**2.1**	Get familiarized with the computer aided finite element analysis packages which are necessary to solve the engineering problems numerically
3.0	To develop finite element formulations of engineering problems from a variety of application areas including stress, heat transfer, and vibration analysis	**3.1**	Create the mechanical systems to meet thermal and fluid flow requirements for various applications
4.0	Be aware of the limitations of the FEM. Learn to use ANSYS (Commercial finite element programs)	**4.1**	Usage of commercial FE softwares to solve complex engineering problems with an understanding of their limitations
5.0	To develop the students to perform Design optimization, Buckling, Modal, Fatigue and Harmonic analysis	**5.1**	Demonstrate the mechanical components to meet optimization, Buckling, Modal, Fatigue and Harmonic analysis for various applications

Analysis of Mechanical Components – Use of FEA Packages.

1. Analysis of machine elements under Static loads
2. Analysis of an Axi-symmetric problem
3. Modal and Harmonic Analysis
4. Thermal Analysis of mechanical systems
5. Non-linear Structural Contact Analysis
6. Eigen value Buckling Analysis
7. Fatigue Analysis of a component
8. Modeling a component using Pro/E, Importing to ANSYS and Meshing

• Use of kinematics and dynamics simulation software. Analysis of velocity and acceleration for mechanical linkages of different mechanisms

TOTAL : P: 45 = 45 PERIODS

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	2	1	3	3	1	2	3	1
2	2	1	2	2	1	2	3	1
3	3	2	3	3	2	3	3	2
4	2	2	3	3	2	2	2	2
5	2	2	3	2	2	2	2	2
CO (W.A)	**2.2**	**1.6**	**2.8**	**2.6**	**1.6**	**2.2**	**2.6**	**1.6**