MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

Minors as proposed by Mechanical Engineering Department for students of other branches

SCHEME OF INSTRUCTION AND SYLLABI

For B. Tech. Program

(Effective from 2022-23)

DEPARTMENT OF MECHANICAL ENGINEERING

Minors as proposed by Mechanical Engineering Department for students of other branches

S. No.	Name of the Minor
1.	Mechatronics and Automation
2.	Sustainable Energy and Materials
3.	Electric Vehicles and Automobiles

Minor 1: Mechatronics and Automation

S. No.	Details	Code	Name of the Electives	Credit
1.	Minor Course-I	ME*****	Mechatronics	3-1-0 = 4
2.	Minor Course-II	ME*****	Robotics	3-1-0 = 4
3.	Minor Course-III	ME*****	Automatic Control	3-1-0 = 4
4.	Elective Course-I	ME*****	Machine Learning/Condition monitoring and diagnostics/Computer Integrated Manufacturing/ Industrial Automation /Signal Processing/ Micro electro mechanical systems (MEMS)/	3-1-0 = 4

Minor 2: Sustainable Energy and Materials

S. No.	Details	Code	Name of the Electives	Credit
1.	Minor Course-I	ME*****	Solar Energy and applications	3-1-0 = 4
2.	Minor Course-II	ME*****	Energy Management	3-1-0 = 4
3.	Minor Course-III	ME*****	Smart materials	3-1-0 = 4
4.	Elective Course-I	ME*****	Green Hydrogen and Alternative fuels/Mechanics of Composite Materials/Design against Fatigue and Fracture/ Sustainable Engineering/ Sustainable Materials and Green Buildings/Industrial Tribology	3-1-0 = 4

Minor 3: Electric Vehicles and Automobiles

S. No.	Details	Code	Name of the Electives	Credit
1.	Minor Course-I	ME*****	Electric Vehicle Technology	3-1-0 = 4
2.	Minor Course-II	ME*****	Advanced Automobile Engineering	3-1-0 = 4
3.	Minor Course-III	ME*****	Vehicle Management System	3-1-0 = 4
4.	Elective Course-I	ME*****	Hybrid Electric and Fuel Cell Vehicles/Alternative Fuel Technology/Automotive Electronics/ Automotive Materials/Automotive Safety/Vehicle Maintenance	3-1-0 = 4

Minor 1: Mechatronics and Automation

Minor Course-I

Course Code: ME-*****	Mechatronics	Credits: 3-1-0:4

Prerequisites: Mathematics-I

Course Outcomes:

CO1	Students will Understand the concepts of mechatronics and automation systems. Basic components measurement systems & their working principles.
CO2	Students will be able to Identify and draw the equivalent mechatronics model for mechanical and electro-mechanical systems.
CO3	Students will be able to Identify and Classify the types of sensors and actuators, their application and evaluate the range, span, step size etc.
CO4	Students will be able to Apply and analyse the acquired knowledge for designing of actuators, able to prepare the PLC programming by using Ladder diagram for different mechatronics systems and analyse it's functionality. To get familiar with the latest improvements in mechatronics systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	1	1	1	2	2	1	--	3	3
CO2	3	1	2	1	3	1	1	1	2	2	1	--	3	2
CO3	3	1	3	1	3	1	1	1	2	2	1	--	2	2
CO4	3	3	3	3	3	1	1	1	2	2	1	2	3	3

Units	Details	Nos. of Hrs
1	Introduction**s,** Fundamentals of Mechatronics, Past, Present & Future; definitions and concepts. Conventional vs. Mechatronics Systems. Need of Mechatronics in Mechanical Engineering. Classification of Mechatronics etc.	**4**
2	Components of Mechatronic systems, Modelling the Mechatronics system. Mechatronics model of different mechanical systems, their Block diagram with examples.	**6**
3	Sensors and transducers with special reference to Mechatronics, modeling of commonly used sensors, their design concepts etc.	**8**
4	Signals system and actuating devices	**6**
5	Real time interfacing and data acquisition. Microcontroller based control of electric Motors.	**4**
6	Advance Mechatronics systems such as PLCs/SCADA, Industrial Robotics. Case studies etc.	**6**

Text Books:

1. Mechatronics by W. Bolton, Pearson Publication McGraw Hill.

References

1. Mechatronics by Dan Necsulescu, Pearson Publication
2. Mechatronics by David G. Alciatore and Michael B. Histand, TMH Edition.
3. Mechatronics by M. D. Singh and Joshi J. G.
4. Mechatronics System Design by Devdas Shetty and Richard A. Kolk.

NPTEL Link: https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-me54/

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Minor Course-II

Course Code: ME-*****	Robotics	Credits: 3-1-0:4

Prerequisites: Mathematics-I

Course Outcomes:

CO1	Students will understand the concepts of robotics and automation systems. Basic components robot manipulator and their working principles.
CO2	Students will be able to Identify and Classify the types of industrial robots based on kinematic structure, DOF and control system.
CO3	Students will be able to Analyse and evaluate the motion analysis such as Robot kinematics, Motion dynamics, trajectory planning & Robot work envelopes etc. Identify and Classify the types of sensors and actuators.
CO4	Students will be able to Apply and analyse the acquired knowledge for designing the robot, Robot Programming methods for motion planning, gripper force analysis for specific applications. To get familiar with the latest improvements in robotics technology.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	1	1	1	2	2	--	1	3	3
CO2	3	2	2	1	2	1	1	1	2	2	--	1	3	2
CO3	3	3	3	3	3	1	1	1	2	2	--	1	3	3
CO4	3	3	3	3	3	1	1	1	2	2	1	2	3	3

Units	Details	Nos. of Hrs
1	Introduction: Automation and Robotics, An over view of Robotics – present and future applications – classification by coordinate system and control system.	**4**
2	Components of the Industrial Robotics: Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.	**4**
3	Actuators - Introduction – Characteristics of actuating systems – Comparison of actuating systems – Hydraulic devices – Pneumatic devices – Electric motors and stepper motors – Microprocessor control of electric motors.	**6**
4	Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative	**6**

	Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Transformation, Transformation in Robotic Manipulation.	
5	Sensors – Introduction – Sensor characteristics ,Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, – Position sensors – Velocity sensors – Acceleration sensors – Force and pressure sensors – Torque sensors – Micro-switches – Light and Infrared sensors – Touch and Tactile sensors – Proximity sensors – Range-finders– Remote center compliance device. Robotic Assembly Sensors and Intelligent Sensors and Applications etc.	**8**
6	Introduction, Various Teaching Methods, Task Programming, Survey of Robot Level Programming Languages, Typical Programming Examples such as Palletizing, Loading a Machine Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion straight line motion – Robot programming, languages and software packages etc.	**6**

Text Books:

1. FU K S, Gonzalez RC, Lee CSG; Robotics –Control, sensing, TMH Publ.
2. Saeed B. Niku, Introduction to Robotics, Analysis, Systems, Applications, PHI Publications.

References

1. S R Dev, Robotics Technology and Flexible Automation, Tata McGraw Hill
2. Spong Mark and Vidyasagar; Robot Modelling and control; Wiley India
3. Ghosal Ashitava; Robotics Fundamental concepts and analysis; Oxford
4. Saha S; Introduction to Robotics; TMH Publications
5. Murphy ; Introduction to AI Robotics; PHI Learning

NPTEL Link: https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-me39/

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Course Code: ME*****	Automatic Control	Credits: 3-1-0:4

Prerequisites: Mathematics – I and Mathematics – II

Course Outcomes:

CO1	Students will be able to apply the modelling fundamentals to obtain state-space and transfer function models of linear control systems.
CO2	Students will be able to compute the time response of linear control systems.
CO3	Students will be able to compute the frequency response of linear control systems.
CO4	Students will be able to analyse the linear control systems to identify the characteristics of the systems.
CO5	Students will be able to design the linear controller based on the desired characteristics of the systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	-	-	2	2	2	1	2	3	3
CO2	3	3	3	2	3	-	-	2	2	2	1	2	3	3
CO3	3	3	3	2	3	-	-	2	2	2	1	2	3	3
CO4	3	3	3	2	3	-	-	2	2	2	1	2	3	3
CO5	3	3	3	3	3	1	-	2	2	3	1	3	3	3

Unit	Details	No. Hrs
1	Introduction to control, open-loop control, feedback control, Modelling of mechanical, electrical and hydraulic dynamic systems, Properties of Laplace transform, Transfer function modelling, Representation of multiple subsystems: Block diagrams, Signal flow graphs, State-space representation, State-space model solution.	8
2	Time response of first order system, time-constant, Time response of second order systems, Pole locations and Time Response, Transient Response Analysis, Stability analysis using the Routh-Hurwitz test, Relative Stability, Steady state error, PID Controller Design.	7
3	Root locus analysis: Sketching a root locus, Selection of gain from the root locus, Design of Lead and Lag Compensators using the root locus.	6
4	Frequency response analysis: Bode plot, Nyquist plot, Stability Analysis: Nyquist theorem, Stability Margins, Closed loop frequency response, Design of Lead and Lag Compensators using Frequency Domain Techniques.	8
5	Linear discrete time systems: z-transform, mathematical modelling, stability analysis, steady-state error, dynamic performance of discrete time systems	6

Text Books:

1	Automatic Control Systems	B C Kuoand F Golnaraghi	Wiley
2	Modern Control Engineering	K Ogata	Pearson Education.
3	Discrete-Time Control Systems	K Ogata	Pearson Education

References:

1	Control Systems: Principles and Design	M Gopal	Tata McGraw-Hill
2	Automatic Control Engineering	F H Raven	McGraw-Hill
3	Control Systems Engineering	I J Nagrath and M Gopal	New Age International
4	Feedback Control of Dynamic Systems	G F Franklin, J D Powell and A Emami-Naeini	Prentice-Hall
5	Automatic Control	https://nptel.ac.in/courses/112107240	
6	Control engineering	https://nptel.ac.in/courses/108106098	

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Elective Course-I

Course Code: ME*****	Machine Learning	Credits: 3-1-0:4

Prerequisites: NIL

Course Outcomes:

CO1	Student will be able to understand the fundamental issues and challenges of machine learning
CO2	Student will be able to understand a wide variety of learning algorithms
CO3	Student will be able to formulate and evaluate models generated from data
CO4	Student will be able to understand the strengths and weaknesses of various machine learning approaches.
CO5	Student will be able to design and implement various machine learning algorithm for real world problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1	1	2	1	-	2	3	2
CO2	3	3	2	3	3	1	1	1	2	1	-	2	3	3
CO3	3	3	3	3	3	2	2	3	2	2	2	3	3	3
CO4	3	3	2	2	3	-	-	-	2	-	-	2	2	2
CO5	3	3	3	3	3	2	2	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	Basic Concepts: Machine Learning, Supervised learning, Unsupervised learning	3
2	Linear Regression with One Variable: Model representation, Cost function formulation, gradient descent for linear regression, Linear Regression with Multiple Variables: Model representation, Cost function formulation, gradient descent for multiple variables, features and polynomial regression, Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost Function, Simplified Cost Function and Gradient Descent, Multiclass Classification Regularization: Over fitting, Regularized linear and logistic regression	7
3	Neural Network Representation : Physiology of Human Brain, Models of Neuron, Network Architecture, Artificial Intelligence & Neural Network Single Layer Perceptrons: Least mean square algorithm, learning curves learning rate annealing techniques, Perceptron, Perceptron Convergence Theorem. Multi-Layer Feed forward Neural Networks: Multi-Layer Perceptrons, Back Propagation Algorithm, Generalization, Cross Validation, Network Pruning Techniques, Accelerated Convergence of Back Propagation Learning.	7
4	Radial Basis Function Networks: Radial Basis Function Networks, Cover's	4

	Theorem; Regularization Theory, Regularization Networks, Comparison of RBF Networks & Multilayer Perceptron.	
5	Dimensionality Reduction: Hebbian based Principal Component Analysis Adaptive Principal Component Analysis using lateral inhibition; Kernel based Principal Component Analysis. Self Organizing Maps: Self Organizing Map, Properties of the feature Map; Learning Vector Quantization, Contextual maps.	5
6	Support Vector Machine: Large Margin Classification, Kernels, Using an SVM	5
7	Anomaly Detection: Developing and Evaluating an Anomaly Detection System, Anomaly Detection vs. Supervised Learning, Choosing What Features to Use, Multivariate Gaussian Distribution Anomaly Detection using the Multivariate Gaussian Distribution	4

Text Books:

1	Neural Networks: A comprehensive Foundation	S. Haykin	Pearson Education, Inc.
2	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy	MIT Press

References:

1	Introduction to artificial neural systems	Jacek M. Zurada	Jaico Publishing House
2	The Elements of Statistical Learning	T. Hastie, R. Tibshirani, and J. Friedman	Springer
3	Pattern Recognition and Machine Learning	Christopher M. Bishop	Springer

##

Course Code: ME*****	Condition Monitoring and Diagnostics	**Credits: 3-1-0:4**

Pre-requisites: Basic knowledge of science and engineering

Course Outcomes:

CO1	Students will be able to understand the concept of condition monitoring and diagnostics of the systems.
CO2	Students will be able to select appropriate condition monitoring and diagnostics technique in a given system/plant.
CO3	Students will be able to explore the data acquisition system, sensors, signal processing required for condition monitoring of the system.
CO4	Students will be able to analyze and identify the faults in the system.

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO 2	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO 3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO 4	3	3	3	2	3	2	1	1	-	-	-	3	3	3

Unit	Details	No. Hrs
1	**Principles of Maintenance:** Reactive Maintenance, Preventive Maintenance, Predictive Maintenance, Enterprise Resource Planning, Bath Tub Curve, Failure Modes Effects and Criticality Analysis (FMECA)	5
2	**Digital Signal Processing:** Classification of Signals, Signal Analysis, Frequency Domain Signal Analysis, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Signal Demodulation, Cepstrum Analysis	5
3	**Vibration Monitoring:** Principles of Vibration Monitoring, Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Unbalanced Shaft, Looseness, Rub, Bearing Defects, Gear Fault, Faults in Fluid Machines, Case studies.	10
4	**Electrical Machinery Faults:** Construction of an Electric Motor, Faults in Electric Motor, Fault Detection in Electric Motors, MCSA for Fault Detection in Electrical Motors, Instrumentation for Motor Current Signature Analysis, Fault Detection in Mechanical Systems by MCSA, MCSA for Fault Detection in any Rotating Machine, Fault Detection in Power Supply Transformers, Fault Detection in Switchgear Devices, Case studies.	5
5	**Thermography and Wear Debris Analysis :** Thermal Imaging Devices, Use of IR Camera, Industrial Applications of Thermography, Applications of Thermography in Condition Monitoring, Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis, Case studies.	5
6	**Machine Tool Condition Monitoring:** Tool Wear, Sensor Fusion in Tool Condition	5

	Monitoring, Sensors for Tool Condition Monitoring, A Tool Condition Monitoring System	

Text Books:

1	Machinery Condition Monitoring: Principles and Practices	Mohanty, A. R	Taylor and Francis, CRC Press

References:

1	Mechanical fault diagnosis and condition monitoring	Collacott, R.A.	John Wiley
2	Handbook of condition monitoring	Davis, A.	Springer
3	Machinery malfunction diagnosis and correction	Eisenmann, R. C	Prentice Hall

##

Course Code: ME*****	Computer Integrated Manufacturing	Credits: 3-1-0:4

Pre-requisites: NIL

Course Outcome

S.N.	Outcomes
CO1	Understand and apply the basics of CAD-CAM to link with the present industrial requirement.
CO2	Identify the levels of integration and required devices for industrial automation and up graduation requirements.
CO3	Identify the parameters of capacity planning, manufacturing resource planning and their effects on current market trends.
CO4	Evaluate and apply the concepts of industry 4.0 environment and to develop business strategy on the basis of studied parameters.
CO5	Apply and analyse the required knowledge in developing business competencies, ethics and to develop strategy for dynamic customer's requirement.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	3	1	1	-	2	-	1	1	3	3	3
CO2	2	2	3	3	3	2	3	1	1	1	1	2	3	3
CO3	3	3	3	3	1	-	-	2	2	3	-	3	3	3
CO4	3	3	3	3	1	2	2	2	2	3	1	3	3	3
CO5	3	3	3	3	2	2	2	1	2	3	2	3	3	3

Module	Content	No. Hr
1	CIM Concepts: Manufacturing Enterprise: External and Internal Challenges, world-class order-winning criteria, CIM- definition, SME manufacturing wheel, CIM benefits and implementation steps; Manufacturing Systems: Classification, elements or sections of a typical manufacturing organization. Functions and Components of CIM System: Design process, concurrent engineering, Concept of CAD/CAM and CIMS.	**10**
2	Database and Communication in CIM System: Data Communication technologies, Database Management technologies, Automated data collection in shop floor.	**6**
3	Planning and Scheduling Functions in CIM System: Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP).	**7**
4	Group Technology and Cellular Manufacturing: Concept of Group Technology and its Application, Classification and Coding Techniques;	**9**

	Clustering Techniques and Cellular Manufacturing, Flexible Manufacturing Systems. Computer-Aided Process Planning: Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation.	
5	Automated Material Handling Systems Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems. Introduction to Advanced Manufacturing Systems Introduction to Lean Manufacturing systems, Agile Manufacturing systems, Quick Response Manufacturing, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems, Agent-Based Manufacturing Systems, Web-based manufacturing, Virtual Manufacturing.	**8**

Reference Books:

1. James A. Rehg and Henry W. Kraebber, 2005. Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
2. Mikell P. Groover, 2005. Automation, Production Systems and Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
3. Nanua Singh, 1995, Systems Approach to Computer Integrated Design and manufacturing, John Wiley & Sons.

##

Minor Course-III

Course Code: ME-*****	Industrial Automation	Credits: 3-1-0:4

Prerequisites: Workshop and Manufacturing Process, Industrial Engineering

Course Outcomes:

CO1	Students able to understand the concepts of automations, automation strategy and advanced automation functions.
CO2	Students able understand the different components and tools for automation process
CO3	Students able to understand performances of different automated material handling and storage system
CO4	Students able to understand about the automated production and assembly lines, cellular and flexible manufacturing systems.
CO5	Students able to understand advanced manufacturing production planning and capacity planning system.

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1	1				1	2	1	1	1	2	2	1	2
CO 2	1	2	2	1	1	2	2	2	2	2	2	2	2	2
CO 3	1	1	1	1	1	2	2	2	1	2	2	2	2	2
CO 4	1		2	2	1	1	2	2	1	1	2	2	2	2
CO 5	1	1	1	1		2	2	2	1	1	2	2	2	2

Unit	Details	No. Hrs.
1	Introduction: – need for automation – automation in production systems – automation principles and strategies - hard and soft automation production system - elements of advanced automation functions - levels of automation - modeling of manufacturing systems.	4
2	Introduction to hydraulic, pneumatic, electric controls system. – majorcomponents, symbols and accessories functions of hydraulic system - Design and application of hydraulic circuits of machine tool, press, Mobile hydraulic. Pneumatic system - pneumatic components and function- pneumatic components symbols- Design and application of pneumatic circuits of machine tool. Semi automats-automated-transfer lines - automatic assembly - transfer devices and feeders' classifications and applications-job orienting and picking devices- setting of automats and transfer lines. Introduction to Microprocessors and their applications, Sensors and Principles, PLC system	7

3	Material handling: Introduction, material handling systems and equipment - principles and design, material transport system: transfer mechanisms and equipments – automated feed cut of components, performance analysis, uses of various types of handling systems including AGV and its various guiding technologies. Overview of automatic identification methods.	7
4	Storage system: introduction - storage system performance - location strategies - conventional storage methods and equipments - automated storage systems – analysis of storage systems.	4
5	Automated manufacturing systems: Components, classification, overview of automated production lines – automated assembly systems, group technology and cellular manufacturing – flexible manufacturing cells and systems - components and applications.	6
6	Manufacturing support system: Process planning and concurrent engineering- process planning, CAPP, CE and design for manufacturing, advanced manufacturing planning, production planning and control system, master production schedule, MRP. Capacity planning, shop floor control, inventory control, MRP-II, J.I.T production systems. Lean and agile manufacturing	6
	Total Hours	34

Text Books:

1	Automation, Production Systems and Computer Integrated Manufacturing	Mikell P. Groover	Prentice Hall India
2	Introduction to industrial automation	Manesis, S., & Nikolakopoulos, G	CRC Press

References:

1	Power Hydraulics	Michael J. Pinches and John G	Prentice Hall
2	Basic Fluid Power	DudleytA. Pease and John, J. Pippenge	Prentice Hall
3	Assembly Automation and Product Design	Geoffrey Boothroyd	
4	Product Design for manufacture and Assembly	Joffrey Boothroyd, Peter Dewhurst and Winston A. Knight	CRC Press
5	Industrial Automation: Hands On	Frank Lamb	
6	Industrial Automation and Control https://archive.nptel.ac.in/courses/108/105/108105062		Nptel

Course Code: ME*****	Signal Processing	Credits: 3-1-0:4

Prerequisites: Basic knowledge of Mathematics

Course Outcomes:

CO1	Students will Understand the concepts and explore the various properties of signals and systems.
CO2	Students will be able to uunderstand the concept of control system, Z-Transform, discrete Fourier transform and Laplace transform etc.
CO3	Students will be able to Identify and Classify the types of sensors and actuators, various signal processing devises and their applications for signals and system theory.
CO4	Students will be able to Apply and analyse the acquired knowledge for designing of signal processing devices, able to evaluate the range, span, step size etc. for different signal processing systems and analyse it's functionality. To get familiar with the latest improvements in signals and systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	1	1	1	2	2	1	--	**3**	**3**
CO2	3	1	2	1	3	1	1	1	2	2	1	--	**3**	**2**
CO3	3	1	3	1	3	1	1	1	2	2	1	--	**2**	**2**
CO4	3	3	3	3	3	1	1	1	2	2	1	2	3	**3**

Units	Details	Nos. of Hrs
1	**An introduction to signals and systems**: Signals and systems as seen in everyday life, and in various branches of engineering. Formalizing the common essence and requirements of signal and system analysis from these examples. Energy and power signals, signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance. Classification and Analysis of Systems etc.	**08**
2	**Continuous time and discrete time Linear shift-invariant (LSI) systems**: the impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of linear shift-invariant systems. System representation through differential equations and difference equations.	**05**
3	**Frequency domain representations:** The notion of a frequency response and its relation to the impulse response, Dirichlet conditions for existence of frequency domain representation, Fourier series representation, the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT). Parseval's Theorem. The idea of signal space and orthogonal bases of signals.	**08**
4	**Laplace Transform** :The Laplace Transform for continuous time signals and systems: the notion of eigen functions of LSI systems, a basis of eigen functions, region of convergence, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential	**05**

	equations and system behavior. Generalization of Parseval's Theorem	
5	**Z Transform**: The z-Transform for discrete time signals and systems: eigen functions, region of convergence, system functions, poles and zeros of systems and sequences, z-domain analysis. Generalization of Parseval's Theorem.	**05**
6	**Sampling:** Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold, and so on. Aliasing and its effects. Relation between continuous and discrete time systems. Applications of signal and system theory for Modulation and filtering in communication engineering.	**07**
7	**System realization**: System realization through block-diagram representation and system interconnection. State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role	**03**

Text Books:

1. ***Signals and Systems by A.V. Oppenheim, A.S. Willsky and I. T. Young, Prentice Hall.***
2. ***Signals and Systems by Simon Haykin, Barry Van Veen, John Wiley and Sons (Asia) Private Limited, c1998.***
3. Signal Processing and Linear Systems by B.P. Lathi, Oxford University Press
4. Mechatronics by W. Bolton, Pearson Publication McGraw Hill.

References

1. Signals and Systems by H Hsu , R Ranjan, Schaum's outline series.
2. Signals and Systems - Analysis using Transform methods and MATLAB by M. J. Roberts, Tata Mc Graw Hill Edition.
3. Signals and Systems - Continuous and Discrete by R.F. Ziemer, W.H. Tranter and D.R. Fannin, Prentice Hall Publications.

NPTEL Link: https://archive.nptel.ac.in/courses/117/104/117104074/

Course Code: ME*****	Micro-Electro-Mechanical Systems	Credits: 3-1-0:4

Prerequisites: Basic knowledge of science and engineering

Course Outcomes:

CO1	Students will be able to understand the concept of micro-electro-mechanical systems, its working principles and applications.
CO2	Students will be able to design, simulate and analyse the basic micro sensors and actuators in the micro system.
CO3	Students will gain the knowledge of the MEMS fabrication and manufacturing processes.
CO4	Students will be able to explore new design and applications of MEMS

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	3	2	2	1	1	1	1	1				1	2	2
CO 2	3	2	2	1	1	1	1	1				3	3	3
CO 3	3	3	3	2	3	2	1	1				1	1	1
CO 4	3	3	3	2	3	2	1	1				2	2	1

Unit	Details	No. Hrs
1	**Overview of Micro Electro Mechanical systems (MEMS):** MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization	5
2	**Working Principles of Microsystems:** Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics, Case studies.	5
3	**Engineering Science for Microsystems Design and Fabrication:** Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry, Case studies.	5
4	**Materials for MEMS:** Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials, Case studies.	5
5	**Engineering Mechanics and thermo-fluid Engineering for Microsystems Design:** Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale, Case studies.	7

6	**Fabrication and manufacturing Processes for Microsystems:** Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process, Case studies.	8

Text Books:

1	MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering	Hsu, T.R	John Wiley & Sons, Inc. New Jersey

References:

1	Fundamentals of Microfabrication	Madau, M. J.,	Taylor &Francis
2	Handbook of MEMS: Introduction and Fundamentals	Gad-el-Hak, M.	Taylor &Francis

Minor 2: Sustainable energy and materials

Minor Course-I

Course Code: ME	Solar Energy and Applications	Credits: 3-0-0:3

Prerequisites: Heat and Mass Transfer, Energy Science.

Course Outcomes:

CO1	Understand the basics of solar energy including its production at the Sun, and collection at Earth surface.
CO2	Understand various methods to collect the solar energy and its measurement.
CO3	Applysolar energy to solve various technical problems overcoming their conventional methods for safely realization, betterment of mankind and to protect our planet from effects of climate change such as global warming.
CO4	Analyse the performances of various solar energy applications e.g. Thermal, Photovoltaic and Daylight..

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	2	2	2	2	2	3	3	2
CO2	3	2	2	2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3

Unit	Details	No. Hrs
1	Introduction: Energy saving and Protection of Environment, The Sun, The Earth, Solar spectrum. Global warming and it's effect, Importance of Solar Energy. Solar energy systems and It's types: Active and Passive. A brief overview of various applications of solar energy.	4
2	Solar Radiation: Types of Solar radiation (Terrestrial and Extra-terrestrial regions, Beam radiation, Diffuse radiation), Air mass, Albedo, Irradiance. Attenuation, Sun-Earth Angles, Solar time, Solar radiation on inclined surface and horizontal surface, Measuring Instruments for solar radiation e.g. Pyrheliometer, Pyranometer, Sun-shine recorder.	4
3	Solar Water Heating: Introduction (need & working principle), Heat and mass transfer mechanism, Types of solar water heating systems, Basic energy balance equations, Efficiency and Performance. Solar Air Heating/Cooling: Introduction (need & working principle), Heat	6

	and mass transfer mechanism, Types of solar air heating and cooling systems, Basic energy balance equations, Efficiency and Performance.	
4	Solar Distillation: Introduction (need & working principle), Heat and mass transfer mechanism, Types of solar distillation systems, Basic energy balance equations, Efficiency and Performance. Solar Passive house: Concept of passive house, Solar architecture, Principles of making a solar passive house. Daylight and its Use.	6
5	Photovoltaics: Introduction, Materials and Doping, Fermi level, p-n junction & its characteristics, Photovoltaic effect, Solar Cell, Module, Array and PV Plant, Solar cell efficiency, Fill factor, Packing factor, Hybrid PV-T applications- a brief study.	6
6	Other applications of solar energy: A brief study of Solar cooking, Solar Aquaculture, Solar Greenhouse, Solar cooling, Solar Thermal Power Generation plant etc.	4

Text Books:

1	Solar Energy – Fundaments, Design, Modeling & Applications	G.N. Tiwari	Narosa Publications.
2	Solar Energy	S P Sukhatme, J K Nayak	McGraw-Hill Publications
3	Solar Photovoltaics: Fundamentals, Technologies And Applications	C. S. Solanki	PHI Publications

References:

1	Solar Energy Engineering	S. Kalogirou	Academic Press
2	Solar Photovoltaic Technology and Systems-A manual for technicians, Trainers and Engineers	S. Solanki	PHI Publications
3	Solar Engineering of Thermal Processes	John A. Duffie, William A. Beckman	John Wiley and sons, New York.
4	Principles of Solar Energy	Frank Krieth& John F Kreider	John Wiley and sons, New York.

##

Minor Course-II

Course Code: ME*****	Energy Management	Credits: 3-0-0-3

Prerequisites: Physics, Thermodynamics

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy conservation opportunities in different sectors of the economy.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	-	3	3	-	-	-	-	3	3	-
CO2	3	3	-	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	-	3	-	-	3	-	-	-	-	-	3	2
CO4	-	-	3	-	3	-	3	-	3	3	3	-	-	3

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	5
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	3
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	5
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	5
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	3

Text Books:

1 Energy Systems and Sustainability — Boyle et al — Oxford University Press

2 Renewable Energy — Boyle et al — Oxford University Press

References:

1	Energy efficiency	Eastop and Croft	Longman Scientific and Technical
2	Bureau of Energy Efficiency (BEE)	Ministry of Power	Government of India
3	Our Choice	Al Gore	Bloomsbury Publishing
4	An Inconvenient Truth	Al Gore	Oscar winning documentary
5	Before the flood	Leonardo DiCaprio	National Geographic documentary

##

Minor Course-III

Course Code: ME*****	Smart Materials	Credits: 3-0-0:3

Prerequisites: Material Science and Engineering, Mechanics of Materials & Composite materials

Course Outcomes:

CO1	Student will be able to understand the basics, role, types, design and mechanics of the smart materials.
CO2	Student will be able to understand the various characterization techniques for the smart materials.
CO3	Student will be able to design and develop the smart materials.
CO4	Student will be able to design the novel smart materials for advance applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	1	1			1	3	3	3
CO2	3	2	2	1	1	1	1	1			1	3	3	3
CO3	3	3	3	3	3	2	1	1			3	3	3	3
CO4	3	3	3	2	3	2	1	1			2	3	3	3

Unit	Details	No. Hrs
1	**Introduction to Smart Materials:** Overview of Smart Materials, Advantages and limitations, Applications, Types of smart materials, Piezoelectric Materials, Elecrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials. Magnetorheological Fluids, Electroheological Fluids, Shape Memory Materials, Fiber-Optic Sensors.	6
2	**Fabrication and characterization:** Additive manufacturing, injection moulding, vapor deposition (PVD), vacuum bag molding process. X-ray diffraction (XRD), Raman scattering spectroscopy (RS), Secondary Ion Mass Spectrometer (SIMS), Transmission electron Microscopy (TEM), Fourier-transform infrared reflection (FTIR), Ultraviolet–visible (UV–Vis), Atomic force microcopy (AFM).	6
3	**Ferroelectric materials:** Piezoelectric materials- piezoelectric effect, Direct and converse, parameter definitions, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs	5
4	**Shape memory materials**: Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs.	5
5	**Smart polymers and hydrogels**: Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers,	5

	Approaches to molecular imprinting, Drug delivery using smart polymers, Synthesis, Fast responsive hydrogels, Molecular recognition, Smart hydrogels as actuators, Controlled drug release, Artificial muscles, Hydrogels in microfluidics.	
6	**Smart systems for sustainable applications**: Elastic memory composites, Smart corrosion protection coatings, Self-healing materials, Sensors, Actuators, Transducers, MEMS, Deployment devices, Molecular machines, Nuclear Industries	5

Text Books:

1	Smart Structure and Materials	Brain Culshaw	Artech House – Borton. London
2	Smart Materials and Structures	M. V. Gandhi and_B.So Thompson	Chapman & Hall, London; New York

References:

1. Electro ceramics: Materials, Properties — A.J. Moulson and J.M-Herbert — Wiley/ 2nd Edition, (ISBN: 0471497479).
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors: Materials and Amplifiers — G. Gautschi — Springer, Berlin; New York, 2002 (ISBN:3540422595)
3. Piezoelectric Actuators and wtrasonic Motors — K.Uchino — Academic Publishers, Boston, 1997 (ISBN: 0792398114)
4. https://archive.nptel.ac.in/courses/112/104/112104251/
5. https://www.youtube.com/watch?v=yXHlIowQntk

##

Elective Course-I

Course Code: ME*****	Green Hydrogen and Alternative Fuels	Credits: 3-0-0:3

Prerequisites: Concepts of Thermodynamics, Fluid Mechanics and Heat Transfer

Course Outcomes:

CO1	Students will be able to explain basic concepts of hydrogen energy and advances in this technology
CO2	Students will be able to explain the different formation methods of hydrogen production and its associated challenges in its storage, transportation and safety.
CO3	Students will be able to explain the importance of bio energy in near future along with the conversion techniques of bio energy from biomass and bio waste.
CO4	Students will be able to identify the challenges in the dissemination of bio-energy to the mass and its design and technical aspects.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	1	1	-	-	2	1	-	3	3
CO2	3	2	2	1	-	-	1	-	-	2	-	-	2	1
CO3	2	3	1	3	2	-	2	-	-	3	1	-	2	2
CO4	3	3	2	3	1	1	3	1	1	2	1	2	3	3

Unit	Details	No. Hrs
1	Basics and types of hydrogen, its production technologies, hydrogen generation from fossil fuels, biomass and renewables by different methods, selection criteria for choosing the Electrolyzers. Hydrogen production from electrolysis method, its working principle, classification, criteria for choosing the materials, and different materials used in this method.	8
2	Hydrogen storage and transport, methods of hydrogen storage, characterization methods, challenges of materials and their solutions, selection criteria of nanomaterials, and different nanomaterials used in hydrogen storage. Safety issues associated with Hydrogen energy.	6
3	Biomass, Broad Classifications, Compositions, Characteristics, Properties, Structural Components, Biomass Residues, Utilization through Conversion Routes: Bio-chemical and Thermo Chemical, Bioconversion into Biogas, Mechanism	7
4	Bioconversion of Substrates into Alcohols and Bio diesels; Thermo-Chemical Conversion of Biomass, Conversion to Solid, Liquid and Gaseous Fuels, Pyrolysis, Gasification, Combustion, Chemical Conversion Processes.	6
5	Biogas Production and Characterization, Biogas Digesters, Parameters influencing the biogas production, challenges with biogas technologies, Biogas Purification and upgradation techniques, compressed biogas technologies	6

Text Books:

1	Hydrogen and Fuel Cells: Emerging Technologies and Applications	Bent Sorensen	Academic Press
2	Biomass Gasification, Pyrolysis and Torrefaction,	Prabir Basu,	Elsevier
3	Renewable Energy Resources	Twidell, J. and Tony W.,	Taylor & Francis

References:

1	Hydrogen Energy Challenges and Solutions for a Cleaner Future	Bahman Zohuri	Springer Singapore
2	Biomass Gasification and Pyrolysis Practical Design	Prabir Basu	Elsevier
3	Biogas Technology	Liangwei Deng, Yi Liu, Wenguo Wang	Springer Singapore

##

Course Code: ME*****	Mechanics of Composite Materials	Credits: 3-0-0:3

Prerequisites: Mechanics of Materials, Material science and engineering

Course Outcomes:

CO1	Students will be able to analyze the mechanical behaviour of composite materials over isotropic materials.
CO2	Students will be able to apply constitutive equations of composite materials and understand mechanical behaviour at micro and macro levels.
CO3	Students will be able to determine the stresses and strains relation in composites materials.
CO4	Students will be able to predict the failure of the lamina and laminates composites

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	2	1	1	1	-	-	-	3	3	3
CO2	3	2	2	1	1	1	2	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	-	1	-	3	3	3

Unit	Details	No. Hrs
1	INTRODUCTION TO COMPOSITE MATERIALS: Introduction, Classification: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, nature-made composites, and applications. Fibres- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.	**9**
2	ELASTIC BEHAVIOR OF COMPOSITE LAMINA USING MICROMECHANICS: Introduction, Strength of Materials Approach, Semi-Empirical Models, Elasticity Approach, Volume and Mass Fractions, Density, and Void Content, Evaluation of the Four Elastic Moduli, Ultimate Strengths of a Unidirectional Lamina	**6**
3	ELASTIC BEHAVIOR OF COMPOSITE LAMINA USING MACROMECHANICS:	**6**

	Introduction, Definitions: Stress, Strain, Elastic Moduli, Strain Energy, stress-strain relations for general anisotropic materials, specially orthotropic materials, transversally isotropic materials, orthotropic material under plane stress and isotropic materials, relations between mathematical and engineering constants.	
4	ELASTIC BEHAVIOR OF MULTIDIRECTIONAL LAMINATES: Basic assumptions, laminate code, strain-displacement relations, stress-strain relations of a layer within a laminate, force and moment resultants, Laminate stiffness and laminate compliance, symmetric laminates, balance laminates	**6**
5	FAILURE ANALYSIS AND DESIGN OF LAMINA: Strength Failure Theories of an Angle Lamina: Maximum Stress Failure Theory Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu	**7**
6	FAILURE ANALYSIS AND DESIGN OF LAMINATES: Introduction, Special Cases of Laminates, and Failure Criterion for a Laminate, and Design of a Laminated Composite	**6**

Text Books:

1	Engineering Mechanics of Composite Materials	Isaac and M Daniel,	Oxford University Press
2	Analysis and performance of fibre Composites	B. D. Agarwal and L. J. Broutman	John Wiley & sons, New York

References:

1	Mechanics of Composite Materials	R. M. Jones	Mc Graw Hill Company, New York
2	Analysis of Laminated Composite Structures	L. R. Calcote	Van Nostrand Rainfold, New York
3	Mechanics of Composite Materials	Autar K. Kaw	CRC Publication

##

Course Code: ME*****	Design against Fatigue and Fracture	Credits: 3-0-0:3

Prerequisites: Material Science and Engineering, Mechanics of Materials

Course Outcomes:

CO1	Students will be able tounder stand the concept of fracture mechanics in the design of products and systems.
CO2	Students will be able to formulate the effect of cracks, flaws on mechanical behavior of components.
CO3	Students will be able to analyze and determine the effect of inherent/nucleated cracks and flaws under monotonic and fluctuating load conditions both analytically and experimentally.
CO4	Students will be able to predict the life of components under cyclic loading conditions and apply the knowledge in research and development activity for betterment of the society.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1				3	3	3
CO2	3	2	2	1	1	1	1	1				3	3	3
CO3	3	3	3	2	3	2	1	1				3	3	3
CO4	3	3	3	2	3	2	1	1				3	3	3

Unit	Details	No. Hrs
1	Stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve.	5
2	Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials; Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviors, The stress Intensity factor K, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of K_{IC} with material	7
3	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, Laboratory measurement of K_{IC}	6
4	Micro-mechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design, fail-safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach.	5
5	Cyclic deformation and the strain-life (ε-N) approach, Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth.	6
6	Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories, Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.	6

Text Books:

1	Fracture Mechanics	Michael Janssen, Jan Zuidema and Russell Wanhill	Spon Press (Taylor & Francis Group)
2	Metal Fatigue in Engineering	R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs	John Wiley

References:

1	Fracture Mechanics: Fundamentals and Applications	T.L.Anderson	CRC Press
2	Fundamentals of Fracture Mechanics	J.F.Knott	Butterworths
3	Fatigue Damage, Crack Growth and Life Prediction	F.Ellyin	Chapman & Hall
4	Elementary Engineering Fracture Mechanics	D. Broek	Kluwer Academic
5	Fracture Mechanics with an introduction to micromechanics	Gross and Seelig	Springer
6	Elements of Fracture Mechanics	Prashant Kumar	Tata McGraw Hill
7	Deformation and Fracture Mechanics of Engineering, Materials	R.W. Hertzberg	John Wiley

##

Course Code: ME*****	Sustainable Engineering	Credits: 3-1-0:4

Prerequisites:

Course Objectives

- To have an increased awareness among students on issues in areas of sustainability.
- To understand the role of engineering and technology within sustainable development.
- To know the methods, tools, and incentives for sustainable product-service system development.
- To establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, economic problems.

Expected outcome:

CO1	The student will be The student will be able to understand the different types of environmental pollution problems and their sustainable solutions.
CO2	The student will be The student will be able to work in the area of sustainability for research and education.
CO3	Students will have a broader perspective in thinking for sustainable practices by utilizing the engineering knowledge and principles gained from this course.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	3	1	1	-	2	-	1	1	3	3	3
CO2	2	2	3	3	3	2	3	1	1	1	1	2	3	3
CO3	3	3	3	3	1	-	-	2	2	3	-	3	3	3

Unit	Details	No. Hrs
7	Sustainability- Introduction, Need and concept of sustainability, Social-environmental and economic sustainability concepts, Sustainable development, Nexus between Technology and Sustainable development, Challenges for Sustainable Development. Multilateral environmental agreements and Protocols-Clean Development Mechanism (CDM), Environmental legislations in India-Water Act, Air Act.	4
8	Air Pollution, Effects of Air Pollution- sources, Sustainable waste water treatment, Solid waste- sources, impacts of solid waste, Zero waste concept, 3R concept, Global environmental issues-Resources degradation, Climate change, Global warming, Ozone layer depletion, Regional and Local Environmental Issues. Carbon credits and	6

	carbon trading, carbon foot prints.	
9	Environmental management standards, ISO 14000 series, Life Cycle Analysis (LCA) – Scope and Goal, Bio-mimicking, Environment Impact Assessment (EIA) – Procedures of EIA in India.	4
10	Basic concepts of sustainable habitat, Green buildings, green materials for building construction, material selection for sustainable design, green building certification, Methods for increasing energy efficiency of buildings. Sustainable cities, Sustainable transport.	5
11	Energy sources: Basic concepts-Conventional and non-conventional, solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy.	5
12	Green Engineering, Sustainable Urbanization, industrialization and poverty reduction; Social and technological change, Industrial Processes: Material selection, Pollution Prevention, Industrial Ecology, Industrial symbiosis.	5

Text Books:

Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.

References:

1 Engineering applications in sustainable Design and Development — Bradley. A. S; Adebayo, A. O., Maria, P. — Cengage learning

2 Basic Concepts in Environmental Management — Mackenthun, K. M. — Lewis Publication, London, 1998

3 Environment Impact Assessment Guidelines, Notification of Governments of India, 2006.

4 ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications- GRIHA Rating System.

5 System Analysis of Sustainable Engineering Theory and Applications — Ni bin Chang — McGraw-Hill Professional

6 Renewable Energy Resources — Twidell, J. W. and Weir, A. D. — English Language Book Society (ELBS).

7 An approach for sustainable environment — Purohit, S. S — Green Technology

Course Code: ME*****	Sustainable Materials and Green Buildings	Credits: 3-1-0:4

Prerequisites: Basics concepts of green technology and sustainability, introduction to civil engineering building materials.

Course Outcomes:

CO1	Expose the students to the concepts of sustainability
CO2	Understand the concept of building and conventional engineered building materials
CO3	Understand the concept of conventional engineered building materials
CO4	Make student aware of various green building councils

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	2	1	2	3	2	1	1	1	3	3	3
CO2	2	2	2	2	2	2	2	2	1	2	1	3	2	3
CO3	2	1	2	3	2	2	3	2	1	2	1	3	3	2
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction to sustainability and green building:** Introduction to sustainable materials and the concept of green building, Embodied energy and Operational energy in Building and Life cycle energy, Ecological footprint, Bio- capacity and calculation of planet equivalent.	**8**
2	**Sustainable materials:** Role of Material: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission, Sustainability issues for concrete, Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability.	**8**
3	**Energy and resources consumption:** Reduction in water consumption in concrete, recycled aggregate, Energy for grinding and crushing of cement, aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity. Clay Bricks, Types of kilns, Comparative energy performance, emission performance and financial performance, Indoor air quality.	**8**
4	**Operational energy consumption:** Paints, Adhesive and sealants for use in building, Volatile organic content (VOC) emission issues and indoor air quality for Sustainability and Health hazard. Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm.	**8**
5	**Energy and resources balance:** Radiation budget, Surface water balance, Effects of trees and microclimatic modification through greening. Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency.	**8**
6	**Energy codes:** ECBC requirement, Concepts of Overall Thermal Transfer Value (OTTV), Green Performance rating, requirements of Leadership in Energy and Environmental Design (LEED), Green Rating for Integrated Habitat Assessment (GRIHA) and Indian Green Building	**8**

	Council (IGBC).	

Text Books:

1	Sustainability Engineering: Concepts, Design and Case Studies	Allen, D. T. and Shonnard, D. R.	Prentice Hall
2	Engineering applications in sustainable design and development	Bradley. A.S; Adebayo, A.O., Maria	Cengage learning
3	Environment Impact Assessment Guidelines	Notification of Government of India	
4	Basic Concepts in Environmental Management	Mackenthun, K.M.	Lewis Publication London
5.	GRIHA Rating System	New Delhi Bureau of Energy Efficiency	Publications- Rating System TERI Publications

Course Code: ME *****	Industrial Tribology	Credits: 3-1-0:4

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to understand the fundamentals of friction, wear and lubrication with reference to industrial applications
CO2	Students will be able to relate friction and wear of engineering materials
CO3	Students will be able to evaluate friction and wear of various engineering materials with different surface contacts.
CO4	Students will be able to select lubricants and /or surface treatment method to reduce friction and wear

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	3	1		2				2	2	3	3
CO2	3	1	2	3	1		2				2	2	3	3
CO3	3	3	3	2	2		2				2	3	3	3
CO4	3	3	3	2	3		3				2	3	3	3

Unit	Details	No. Hrs
1	**Definition and History of Tribology, Industrial Significance of Tribology Surface topography and surfaces in contact**: Measurement of surface topography, Quantitative surface roughness, Topography of engineering surfaces, Contact between surfaces.	6
2	**Friction:** Theories of friction, Friction of metals, ceramics, lamellar solids and polymers, Atomic scale friction, Micro scale friction.	6
3	**Wear:** Types of wear mechanisms: sliding, erosion, abrasion, etc,; Wear testing methods; Estimation of wear rates; Types of particles present in wear debris. **Wear of materials**: metals, ceramics, polymers, composites.	6
4	**Lubrication:** Types of lubricants and their industrial uses, SAE classification, recycling, disposal of oils, properties of liquid and grease lubricants, lubricant additives, general properties and selection. Hydrostatic Lubrication: Principle, general requirement, types and applications. Hydrostatic Lubrication: Principle, Theories of lubrication, types and applications. Air/ Gas Lubricated bearings: Advantages and disadvantages, Hydrodynamic journal bearing, hydrodynamic thrust bearing, Analysis. Effect of lubrication on friction and wear of metals, ceramics, polymers and composites..	12
5	**Surface engineering in 38 Tribology :** Surface treatment methods to reduce friction and wear	3
6	**Case studies on friction, wear and lubrication**	3

Text Books:

1	Engineering Tribology	G. W. Stachowiak and A. W. Batchelor	Butterworth-Heinemann;4th edition
2	Friction, wear, Lubrication	Ludema, K.C.	CRC Press, NY.
3	Tribology: Friction and Wear of Engineering Materials	Ian Hutchings and Philip Shipway	Butterworth-Heinemann; 2nd edition

References:

1	Introduction to Tribology	Bharat Bhushan	John Wiley and Sons, New York, USA
2	Surface Engineering for Corrosion and Wear Resistance	J. R. Davis and Associates	ASM International, Materials Park, OH, USA, 2001
3	The principles of Lubrication	Cameron A.	Longman, London
4	Industrial Tribology: Tribosystems, Friction, Wear and Surface Engineering, Lubrication	Theo Mang, Kirsten Bobzin, Thorsten Bartels	Wiley-VCH
5	Handbook of Hard Coatings: Deposition Technologies, Properties and Applications	Bunshah, R. F.,	Noyes Pub. Park Ridge, New Jersey, U. S. A./William Andrew Publishing, LLC, Norwich, New York, U.S.A.
6	Standard Handbook of Lubrication Engineering	O' Conner and Royle	McGraw Hills

##

Minor 3: Electric Vehicles and Automobiles

Minor Course- I

Course Code: ME*****	Electric Vehicle Technology	Credits: 3-0-0:3

Prerequisites: Basic Electrical Engineering

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand about basics of electric vehicle.
CO2	Students will be able to understand about drives and control systems of electric vehicles.
CO3	Students will be able to select motor, battery, battery indication system for EV applications.
CO4	Students will be able to design battery charger for an EV.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	1	1	3	1	-	-	-	-	1	2	1
CO2	3	-	-	1	1	3	1	-	-	-	-	2	2	1
CO3	1	3	3	3	2	3	1	1	-	-	2	2	3	2
CO4	1	2	3	2	3	2	2	1	-	-	1	2	3	3

Unit	Details	No. Hrs
1	**Introduction to Electric Vehicle:**Types and working mechanisms of Electric Vehicles, Components of Electric Vehicles, Chassis /Battery/Charger/etc., Standard Materials and its properties for components used in ElectricVehicles, Frame and Chassis of Electric Vehicles, braking systems in EVs, planetary gears, clutches, differentials, all-wheel drive regenerative braking mechanisms, Brake strategies (Series and Parallel), Braking torque distribution principle, electro-mechanical hybrid braking system.	10
2	**Energy Storage Systems (ESS):** Types of Batteries, their working mechanisms and characteristics, Applications of Batteries and ultracapacitors in Electric Vehicles, Comparison between different cell chemistry w.r.t. specific power, specific energy, safety, lifespan, performance, cost etc.	7
3	**Analysis of ESS:**Battery design parameters for several Electric Vehicles, Battery Architecture, Battery passive components sizing, Isolation requirements, Manufacturing of batteries, Battery modelling, form cell to pack, Battery pack and design issues, Failures of batteries, Battery Pack Performance & Safety testing standards, Battery management systems, Overview of safety circuits like over voltage and under voltage protection, pre-charge circuit, isolation monitoring, HVIL (high voltage interlock loop), MSD (manual service disconnect), Fuses etc., Overview of favorable and unfavorable storage conditions, impact of temperature on batteries.	8
4	**Mobility and Connectors:**Various types of chargers and energy management	6

	strategies, Connected Mobility and Autonomous Mobility- Emobility. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,	
5	**Drives for EV:**Introduction to Electromagnetic Energy Conversion; Electric drivetrain system; System design considerations, rating and sizing of electric drivetrain components; Machines and drives for traction and EVs: Permanent Magnet Synchronous Motor (PMSM), Permanent Magnet Brushless DC motors(PMBLDCM), Switched reluctance motors, synchronous reluctance motor, induction motor (IM); Control of Electric Drives; Bidirectional DC-DC converters.	5

Text Books:

1	Electric Vehicle Technology Explained	James Larminie, John Lowry	John Wiley & Sons, Ltd.
2	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Husain	Iqbal Husain

References:

1	Electric Vehicles: Modern Technologies and Trends	Nil Patel, Akash Kumar Bhoi, Sanjeevkumar Padmanaban, Jens Bo Holm-Nielsen	Springer Singapore
2	Battery Management Systems of Electric and Hybrid Electric Vehicles	Nicolae Tudoroiu (editor)	MDPI AG
3	Heavy-Duty Electric Vehicles: From Concept to Reality	Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi	Butterworth-Heinemann
4	Rechargeable Lithium-Ion Batteries: Trends and Progress in Electric Vehicles	Thandavarayan Maiyalagan (editor), Perumal Elumalai (editor)	CRC Press

##

Minor Course- II

Course Code: ME*****	Advanced Automobile Engineering	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Engineering Mechanics, Automobile engineering (basic course)

Course Outcomes:

CO1	Students will be able to identify different types of automobile structures, body components and body interiors and how their design differ.
CO2	Students will able to understand and analyze various chassis design and stability of automobiles.
CO3	Students will be able to identify various modern steering and suspension systems and will able to analyze load associated with these systems.
CO4	Students will able to analyze vehicle safety related issues and vehicle design parameters that leads to increased safety and methods to reduce vehicle noise.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	3	3	2	1	2	-	2	2	2
CO2	3	2	2	2	2	3	3	2	1	2	-	2	3	3
CO3	3	2	2	2	2	3	3	2	1	2	-	2	3	3
CO4	3	2	2	1	2	3	3	2	1	2	-	2	3	2

Unit	Details	No. Hrs
1	**Introduction and overview** –Beginnings Growth and refinement	4
2	**Vehicle Structure, Body Components and Body Interiors:** Basic requirement of stiffness and strength Vehicle structure types, Demonstration of Simple Structural Surfaces (SSS), Bumpers, Grilles, Sill covers and side air bags, outer moldings, Weather strips, Glass and Mirrors, Seat Belt Restraint system-Air-Bag, components of Air- Bag, Dash Board	8
3	**Chassis**: Vehicle and body centre of gravity and handling properties, axle weight and axle centre of gravity, body weight and body centre of gravity, Braking behavior –stability, anti dive control, traction behavior.	8
4	**Steering and Suspension systems:** types-limitations. Hydraulic, electro hydraulic and electrical power steering, steering column, steering damper. Vehicle weights and axle loads, Shock absorbers, spring damper units, roll center analysis, load due to gyroscopic force on suspension, total load on suspension.	8
5	**Automotive vehicle safety, Testing and Noise Control:** basic concepts of vehicle safety, techno legal issues- ethics, testing of automotive components, failure investigations, safety factors, designs for uncertainty, crash testing. Interior noise, Engine noise, Road noise, wind noise, brake noise, Interior noise: Assessment and control	8

Text Books:

1	The Motor Vehicle	Newton and Steed	Butterworth-Heinemann
2	Vehicle Body Engineering	J. Powloski	Business Books Ltd
3	Tire and Vehicle Dynamics	Hans B Pacejka	Elsevier Ltd
4	Automotive vehicle safety	George A Peters & Barbara J Peters	CRC Press

References:

1	Advanced Vehicle Technology	Heinz Heisler	Butterworth-Heinemann
2	The Automotive Chassis	J. Reimpell, H Stoll	SAE International
3	Automotive Engineering Fundamentals	Richard Stone and J K Ball	SAE International
4	Automotive Body	Lorenzo Morello	Springer
5	Automotive Engineering (Power Train, Chassis system and Vehicle Body)	David A Crolla	Elsevier collection
6	Road Vehicle Dynamics	Rao V Dukkipati	Springer
7	Highway Design & Traffic Safety Engineering Handbook	Ruediger Lamm	McGraw-Hill Education
8	The handbook of road safety measures	Rune Elvik, Truls Vaa, Alena Hoye, Michael Sorensen	Emerald Group Publishing

##

Minor Course- III

Course Code: ME*****	Vehicle Management System	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Engineering Mechanics, Electrical Engineering and Automobile Engineering.

Course Outcomes:

CO1	Students will able to acquire an overview of automotive components, subsystems, and basics of Electronic Engine Control in today's automotive industry
CO2	Students will able to use available automotive sensors and actuators while interfacing with microcontrollers / microprocessors during automotive system design
CO3	Student will able to understand the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.
CO4	Students will able to design and implement the electronics that attribute the reliability, safety, and smartness to the automobiles, providing add-on comforts and get fair idea on future Automotive Electronic Systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	3	2	1	2	1	3	2	2
CO2	3	3	3	2	2	2	2	2	1	2	1	3	3	2
CO3	3	3	3	2	2	2	3	3	1	1	1	3	3	3
CO4	3	3	3	2	2	2	3	3	1	1	1	3	3	3

Unit	Details	No. Hrs
1	**Automotive Sensors & Actuators:** Hall Effect, hot wire, thermistor, piezo electric, piezoresistive, based sensors. Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, stepper motors, relays, detonation sensor, emission sensors.	**10**
2	**Digital Engine Control System:** Open loop and close loop control system, engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics, future automotive electronic systems, Electronic dash board instruments – Onboard diagnosis system.	**8**
3	**SI Engine Management:** Feedback carburetor system, throttle body injection and multi point fuel injection system, injection system controls, advantage of electronic ignition systems, three way catalytic converter, conversion efficiency versus lambda. Layout and working of SI engine management systems like Bosch Monoj etronic, L-Jetronic and LH-Jetronic. Group and sequential injection techniques. Working of the fuel system components. Advantages of electronic ignition systems. Types of solid state ignition systems and their principle of operation, Contactless electronic	**10**

	ignition system, Electronic spark timing control.	
4	**CI Engine Management:** Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Layout of the common rail fuel injection system. Working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter, EGR valve control in electronically controlled systems.	**10**

Text Books:

1	Automobile Electrical & Electronic Equipments	Young, Griffitns	Butterworths, London.
2	Understanding Automotive Electronics	Wiliam B. Ribbens	Butterworth–Heinemann
3	Gasoline Engine Management	Robert Bosch	SAE Publications
4	Diesel Engine Management	Robert Bosch	SAE Publications

References:

1	Understanding Automotive Electronics	Bechfold	SAE
2	Automobile Electronics	Eric Chowanietz	SAE
3	Automotive Computer & Control System	Tomwather J. R., Cland Hunter	Prentice Inc. NJ
4	Automobile Electrical & Electronic Systems	Tom Denton	Allied Publishers Pvt. Ltd

##

Elective Course- I

Course Code: ME*****	Hybrid Electric and Fuel Cell Vehicles	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Material Science, Internal Combustion Engines, Automobile Engineering, Advanced Automobile Engineering

Course Outcomes:

CO1	Students will be able to understand and analyze different types of Fuel cells, its operation, and performance
CO2	Students will be able to quantify fuel cell processing using codes and standards.
CO3	Students will be able to comprehend basic concept of Hybrid and Electric traction.
CO4	Students will be able to understand the need and environmental importance of Hybrid technology and analyze it.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	3	3	2	3	3	2	2	3	3	3	3
CO2	3	2	3	3	3	2	3	3	2	2	2	3	3	3
CO3	3	2	3	3	2	2	3	3	2	2	2	3	3	3
CO4	3	3	3	3	3	3	3	3	2	2	3	3	3	3

Unit	Details	No. Hrs
1	**Fuel Cell Technology**-Introduction to Electrochemistry, Unit Cells, Fuel cell stacking, Fuel cell Types (Polymer Electrolyte Fuel cell, Alkaline Fuel cell, Phosphoric acid Fuel cell, Molten carbonate fuel cell, and Solid oxide fuel cell), and Timeline of introduction of fuel cell technology in automobiles.	**8**
2	**Fuel Cell Performance-**Role of Gibbs free energy and Nernst Potential, Cell Energy balance, Cell efficiency, Performance variables, various mathematical models. Polymer Electrolyte Fuel cell-Cell Components, PEFC system Performance, Alkaline Fuel Cell-Cell component, Performance.	**6**
3	**Introduction to Fuel cell Hybrids:** Fuel cell Auxiliary Power Systems, Sample Calculations-Fuel cell Calculations, Fuel Processing Calculations for PEFC, AFC. Fuel cell related codes and Standards	**6**
4	**Hybrid Electric Technology and Electric drive trains**-Introduction, History, Environmental importance, Basic concept of Hybrid Traction, Basic concept of electric traction, Introduction of electric components used in electric vehicles. Principles of Hybrid Electric Drive trains, Architectures, Hybrid control Strategies – Parallel Hybrid, Series Hybrid – (Charge Sustaining, Charge Depleting), Low-Voltage Storage System.	**8**
5	**Hybrid Vehicle Technology-**Sizing the drive system: Matching the electric machine and the Internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, and supporting subsystems. Energy Management Strategies in hybrid and electric vehicles, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a	**8**

	Battery Electric Vehicle (BEV).	

Text Books:

1	Fuel Cell Technology Handbook	Hoogers, G., Edr.	CRC Press
2	Fuel Cell Systems Explained	Larminie, J. and Dicks, A.	John Wiley & Sons, Ltd
3	Vehicular Electric Power Systems	Ali Emadi, Mehrdad Ehsani, John M. Miller	Marcel Dekker, Inc.

References:

1	Fuel Cell Handbook	EG&G Technical Services, Inc.	National Energy Technology Laboratory
2	Electric and Hybrid Vehicles	Tom Denton	Institute of the Motor Industry

##

Course Code: ME*****	Automotive Electronics	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand the need of safety of electronics in automobiles, electronic circuit fundamentals and basic test equipment.
CO2	Analyse vehicle electronic circuits.
CO3	Outline the working of batteries, starting systems, charging systems, ignition systems and auxiliaries.
CO4	Understand the working of sensors and ECU

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO3	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction:** Overview of the course, Examination and Evaluation patterns, History of Automotive electronics. **Safety and Communication:** Safe working practices-work cloths, eye protection, fire protection, battery safety. Working as an electricity / electronics technician-your toolbox, access to wiring diagrams and repairs information, communicating with the customer, working around air bags. **Circuit fundamentals and basic test equipment:** voltage, current, resistance, circuits components, series and parallel circuits, purpose of voltmeters, measuring voltage drop, connecting the voltmeter, types of ammeters, current probes, reading and interpreting ohmmeter readings, continuity testing.	**6**
2	**Vehicle circuits:** circuit components, analysing series and parallel circuits, control circuits, diagnosing open and short circuits. **Digital Storage Oscilloscope:** voltage and time setting, DSO trigger and slope, using a current probe with DSO, using the DSO‟s multiple-trace capability. **Electronic fundamentals:** solid state devices, electronic control input devices, diagnosing and servicing electronic control input devices, integrated circuits as input devices, diagnosing and servicing ICs, oxygen sensors, diagnosing and servicing oxygen sensors.	**8**
3	**Wiring diagrams and Batteries:** wiring diagram symbols, using the wiring diagram as aservice tool, automotive batteries, diagnosing batteries, servicing batteries. **Starting and charging systems:** starting circuits, solenoid shift starters, diagnosing and servicing solenoid shift starters systems, positive engagement starters, diagnosing and servicing positive engagement starting system, gear-reduction starters, diagnosing gearreduction starters, charging	**6**

	system overview, field circuits, diagnosing and servicing the charging system.	
4	**Ignition systems and accessories:** secondary ignition systems, servicing the secondary ignition system, primary ignition system, diagnosing and servicing distributed primary ignition systems, distributor less ignition secondary circuits, diagnosing and servicing the secondary ignition system on a distributor less vehicles, distributor less ignition primary circuits, diagnosing and servicing the primary circuit on a distributor less ignition system. Lighting circuits, diagnosing lighting circuits, defogger, horn, and windshield wiper circuits, diagnosing defogger, horn, and windshield wiper circuits, motor driven accessories, diagnosing motor driven accessories	**8**
5	**Cooling of Electronics Equipment:** Cooling load of electronics equipment, thermal environment, Electronics cooling in automotive systems, air cooling, liquid cooling, and immersion cooling. **Electronic control units and sensors:** Vehicle sensors-speed, temperature, fuel level, battery condition, emissions, feedback circuits.	**8**

Text Books:

1	Automotive Technology, Electricity and Electronics	Al Santini	Cengage Publishers, 2011
2	Understanding Automotive Electronics, 6th Edition	William Ribbens	Elsevier

Course Code: ME*****	Alternative Fuels Technology	Credits: 3-0-0

Prerequisites: Engineering Thermodynamics, Internal Combustion Engines

Course Outcomes:

CO1	Students will able to understand about the various alternative fuels available and its properties
CO2	Students will able to determine various properties of bio fuels and their significance in IC engines.
CO3	Student will able to analyze the various gaseous alternative fuels for IC engine applications
CO4	Students will able to explain the concepts of Electric, Hybrid and Fuel Cell Vehicles.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO3	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Need for alternate fuel:** Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars	**6**
2	**Alcohols as Fuels**: Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines.	**8**
3	**Vegetable Oils and Biodiesel as Fuels:** Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, preheating Transesterification and emulsification of Vegetable oils - Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines.	**6**
4	**Hydrogen, Biogas, Natural Gas and LPG as Fuels:** Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen. Production methods of Biogas, Natural gas and LPG. Properties studies. CO_2 and H_2S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines.	**8**
5	**Electric, Hybrid and Fuel Cell Vehicles:** Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles. System components, Electronic control system – Different configurations of Hybrid vehicles. Power split device. High energy and power density batteries – Basics of Fuel cell vehicles.	**8**

Text Books:

1	Handbook of Alternative Fuel Technologies	Sunggyu Lee James G. Speight Sudarshan K. Loyalka	CRC Press, Taylor and Francis Group
2	Biodiesel Handbook	Gerhard Knothe, Jon Van Gerpen, Jargon Krahl	AOCS Press Champaign
3	Alternative Fuels: The Future of Hydrogen	Michael F. Hordeski	The Fairmont Press
4	Hybrid, Electric and Fuel-cell Vehicles	Delmar Cengage Learning	Delmar Cengage Learning

References:

1	Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines	Akhilendra Pratap Singh, Dhananjay Kumar, Avinash Kumar Agarwal	Springer
2	Electric, Hybrid, and Fuel Cell Vehicles	Dr. Amgad Elgowainy	Springer Science
3	Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.).		SAE Publication

##

Course Code: ME*****	Automotive Materials	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand and select suitable materials for automotive applications
CO2	Distinguish between the materials requirements for automobiles interior and exterior
CO3	Understand and Select advanced materials for specific automobile components.
CO4	. Comprehend Ashby charts for material selection

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	2	2	2	1	1	1	3	2	2
CO2	2	2	2	2	2	2	2	1	1	2	1	3	3	3
CO3	2	2	2	3	2	2	3	1	1	2	1	3	3	2
CO4	2	2	3	3	2	2	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction to Automotive Materials:** Introduction to common engineering materials; metallic and non-metallic automotive materials. Materials and processes with relevance to automotive applications. Advanced materials, light weight material, nano material, and synthesis and in-situ materials for automotive applications, corrosion, Standards for automotive materials.	**6**
2	**Materials For The Interior:** Various high performance plastics and composites used in making of dashboards and their processing. Materials used in Flooring, dashboard silencer, headliner, door trim, baffles, rear shelf and their functionality. Car seat-considerations and materials used. Air bag materials used and their testing. Fabrics used in upholstery and their properties requirements	**8**
3	**Materials For The Exterior:** Application of various new materials including various types of composites in making of car bodies, bonnet, Alloy wheels and the processing method/s used to shape these parts. Reinforcement of fibres in composites - Woven fabrics - Non woven random mats - Various types of fibres in PMC processes - Hand lay-up processes - Spray up processes - Compression moulding - Reinforced reaction injection moulding -Resin transfer moulding -Filament winding - Injection moulding. Fibre reinforced plastics(FRP), Glass fibre reinforced plastics (GFRP)	**8**
4	**Smart Concepts for Automobiles:** Relevance of smart materials in the automobile industry, Recent developments in smart automobiles and Smart engines, Use of Electro- or magneto-rheological engine mounts. Engine blocks-cast iron, aluminium alloys. New trends in engines. Suspension systems: Use of MR fluids and ER fluids in dampers. Fuel Injector materials: high melting point materials-Use of ceramics as fuel injectors. Sintered Friction materials: Powder metallurgy process for making disc brake pads	**6**
5	**Selection Of Materials:** Introduction to Ashby charts for making a good selection of materials for different systems in automobiles. Case studies for materials developments by Ferrari, Land Rover, Honda, and FIAT in the making of a automobiles.	**4**

Text Books:

1	Material Selection in Mechanical Design	Michel F Ashby	Butterworth Heinemann
2	Automotive Engineering: Lightweight, Functional and Novel Materials	Cantor B, Johnston, Colin Grant and Patrick	Taylor & Francis
3	Composite materials	K.K Chawla	Springer - Verlag

Reference Books:

1	Material and Design: The Art and Science of Material Selection in Product Design	Michel F Ashby	Butterworth Heinemann
2	Composite materials: Engineering and Science	F.L. Mathews and R.D Rawlings	Chapman and Hall, London, England, 1st edition
3	Composite materials	K.K Chawla	Springer - Verlag

Course Code: ME*****	Automotive Safety	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Identify safety systems necessary for automobiles
CO2	Understand active and passive safety systems
CO3	Design and develop automobile safety systems
CO4	Design and develop automobile comfort and convenience systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	2	2	2	2	2	1	2	1	3	3	3
CO3	2	2	2	3	2	2	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction:** Design of the body for safety, energy equation, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.	**6**
2	**Safety Concepts:** Active safety, driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact.	**8**
3	**Safety Equipment's:** Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, tiltable steering wheel, air bags, electronic system for activating air bags, bumper design for safety	**6**
4	**Collision Warning And Avoidance:** Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions	**8**
5	**Comfort And Convenience System:** Steering and mirror adjustment, central locking system , Garage door opening system, tyre pressure control system, rain sensor system, environment information system.	**8**

Text Books:

1 Automotive Handbook Bosch SAE publication
2 Automotive Mechanics Volume One Ed May McGraw Hill Publications
3 Automotive Mechanics Volume Two Ed May McGraw Hill Publications

Course Code: ME*****	Vehicle Maintenance	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand and diagnose engine maintenance and its trouble shooting.
CO2	Understand and diagnose the transmission and driveline maintenance
CO3	Understand and diagnose the steering, braking, suspension and wheel maintenance and its trouble shooting.
CO4	Understand and diagnose air conditioning and electrical systems maintenance

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	2	1	2	3	2	1	1	1	3	3	3
CO2	2	2	2	2	2	2	2	2	1	2	1	3	2	3
CO3	2	1	2	3	2	2	3	2	1	2	1	3	3	2
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Engine And Engine Subsystem Maintenance :** Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system - Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls	**6**
2	**Transmission And Driveline Maintenance:** Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of cross and yoke joint and constant velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies- fault diagnosis.	**8**
3	**Steering, Brake and Suspension Maintenance:** Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers. Dismantling and assembly procedures. Maintenance and Service of steering inkage, steering column, Rack and pinion steering, Recirculating ball steering service- Worm type steering, power steering system	**6**
4	**Wheel Maintenance:** Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation. Inspection.	**4**
5	**Auto Electrical And Air Conditioning Maintenance:** Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging- Fault diagnosis Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.	**8**

Text Books:

1	Automotive Handbook	Bosch	SAE publication
2	Automotive Mechanics Volume One	Ed May	McGraw Hill Publications
3	Automotive Mechanics Volume Two	Ed May	McGraw Hill Publications
4	Crashworthiness of Vehicles	W. Johnson and A.G Mamalis	MEP, London