Minor Stream: Automation & Robotics

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME024	Elements of Robotics	FC	2			2	50	50	100	-
241ME025	Programming for Robotics	IC	2		1	3	50	50	100	PPSC
241ME026	Digital Manufacturing	IC	3			3	50	50	100	MP-I
241ME027	Advanced Fluid Power & Control Systems	IC	2		1	3	50	50	100	FMHM
241ME028	Robotic Mobility Systems	AC	2		1	3	50	50	100	EOR
241ME029	Control of Robotic System	AC	2		1	3	50	50	100	RMS
241ME030	AI for Robotics	AC	2		1	3	50	50	100	EOR
241ME031	Robotic Operating System	AC	2		1	3	50	50	100	DAP
241ME032	Advanced Robotic Operating System	AC	2		1	3	50	50	100	ROS
241ME033	Field & Service Robotics	AC	2		1	3	50	50	100	PFR
241ME034	Robotic Process Automation (Industry Partnered Certification Program)	AC	3			3	50	50	100	EOR
	Total		**24**		**8**	**32**				

Minor Stream: Thermal Engineering

THERMAL	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME035	Power Plant Engineering	FC	2			2	50	50	100	-
241ME036	Sustainable Energy Systems	FC	3			3	50	50	100	-
241ME037	Solar Energy Systems	FC	3			3	50	50	100	-
241ME038	Alternative Fuels for IC engines	IC	3			3	50	50	100	ICE
241ME039	Fuel Cell Technology	IC	3			3	50	50	100	ICE
241ME040	Refrigeration & Air Conditioning	IC	2	1		3	50	50	100	ETD
241ME041	Hydraulic Machinery & Systems	IC	3			3	50	50	100	FMHM
241ME042	Cryogenic Engineering	AC	3			3	50	50	100	R&AC
241ME044	Energy Storage Systems	AC	3			3	50	50	100	BEEE
241ME045	Gas Dynamics & Jet Propulsion	AC	2	1		3	50	50	100	HPE
241ME046	Computational Fluid Dynamics	AC	2	1		3	50	50	100	HT, FMHM
	Total		**29**	**3**		**32**				

Minor Stream: Automotive Engineering

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME047	Automotive Electrical & Electronics	FC	2			2	50	50	100	BEEE
241ME048	Automotive Maintenance	IC	2		1	3	50	50	100	AE
241EE054	Hybrid & Electric Vehicles	IC	3			3	50	50	100	BEEE
241ME049	Electronic Engine Management System	IC	3			3	50	50	100	HEV
241ME050	Automotive Certification & Homologation	IC	3			3	50	50	100	AE
241ME051	Vehicle Infotronics	IC	3			3	50	50	100	AEE
241ME052	Automotive Aerodynamics	AC	3			3	50	50	100	FMHM, AE
241ME053	Automotive Noise Vibration & Harshness	AC	3			3	50	50	100	DOM
241ME054	Vehicle Stability & Control	AC	3			3	50	50	100	AE
241ME055	Special Purpose Vehicles	AC	3			3	50	50	100	AE
241ME056	Automotive & Pedestrian Safety	AC	3			3	50	50	100	AE
	Total		**31**		**1**	**32**				

Minor Stream: Design and Manufacturing

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME057	Plant Layout & Material Handling	FC	2			2	50	50	100	-
241ME059	Additive Manufacturing	IC	3			3	50	50	100	MF - I
241ME060	Composite Materials	IC	3			3	50	50	100	SSP/MP
241ME061	Design for Manufacturing	IC	3			3	50	50	100	MSD
241ME062	Industrial Automation	IC	3			3	50	50	100	MF - I
241ME063	Flexible Manufacturing System	IC	3			3	50	50	100	MF - I
241ME058	Industry 5.0 for Engineers	AC	3			3	50	50	100	-
241ME064	Design of Transmission Systems	AC	2	1		3	50	50	100	MD
241ME065	Advanced Mechanics of Solids	AC	2	1		3	50	50	100	MSD
241ME066	Mechanical Vibrations	AC	2	1		3	50	50	100	DOM
241ME067	Condition Monitoring	AC	3			3	50	50	100	MV
	Total		**30**	**2**		**32**				

Minor Stream: Advanced Specialization on Electric Vehicles (Mechanical) Industry Integrated Program- L & T

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241EE041	Foundations of EV & Hybrid Vehicles	FC	3			3	50	50	100	-
241ME068	Automotive Mechanics for EV	IC	2			2	50	50	100	MF - I
241ME069	EV Mechanical Design Development & Analysis	IC	3			3	50	50	100	MSD
241ME070	EV Product Development, Homologation & Hydrogen FCEV	IC	3			3	50	50	100	AE
241EE042	EV Battery Technology & Powertrain Development	IC	3			3	50	50	100	BEEE
241ME043	EV Charging Infrastructure, Vehicle Testing & Homologation	IC	3			3	50	50	100	BEEE
241EE044	EV Power Electronics & Embedded Systems	AC	3			3	50	50	100	BEEE
241ME071	EV Data Analytics & Cyber Security	AC	3			3	50	50	100	MD
241ME072	EV FEA Analysis	AC	3			3	50	50	100	MSD
241ME054	Vehicle Stability & Control	AC	3			3	50	50	100	AE
241ME056	Automotive & Pedestrian Safety	AC	3			3	50	50	100	AE
	Total		**32**			**32**				

 # L&T Syllabus for the industry partnered courses will be released in the department as and when required.

Minor Stream Syllabus

Minor Stream: Automation & Robotics

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME024	Elements of Robotics	FC	2			2	50	50	100	-
241ME025	Programming for Robotics	IC	2		1	3	50	50	100	PPSC
241ME026	Digital Manufacturing	IC	3			3	50	50	100	MP-I
241ME027	Advanced Fluid Power & Control Systems	IC	2		1	3	50	50	100	FMHM
241ME028	Robotic Mobility Systems	AC	2		1	3	50	50	100	EOR
241ME029	Control of Robotic System	AC	2		1	3	50	50	100	RMS
241ME030	AI for Robotics	AC	2		1	3	50	50	100	EOR
241ME031	Robotic Operating System	AC	2		1	3	50	50	100	DAP
241ME032	Advanced Robotic Operating System	AC	2		1	3	50	50	100	ROS
241ME033	Field & Service Robotics	AC	2		1	3	50	50	100	PFR
241ME034	Robotic Process Automation (Industry Partnered Certification Program)	AC	3			3	50	50	100	EOR
	Total		**24**		**8**	**32**				

Elements of Robotics

Course Code: 241ME024	L	T	P	C
	2	0	0	2

Course Outcomes:

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

- **CO1:** Describe the historical development and fundamental concepts of robotics.
- **CO2:** Analyze and design robotic drive systems effectively.
- **CO3:** Apply direct kinematics and inverse kinamatics in the mathematical modelling of robot
- **CO4:** Explain the principles and applications of sensors
- **CO5:** Explain robotic systems for sensing and feedback control using microcontroller

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	1	2	2						1
CO2	3	3	2	2	2						2
CO3	3	2	2	2	2						1
CO4	3	3	2	2	2			1	1		2
CO5	3	3	3	2	2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Fundamentals of Robotics

Historical development of Robotics, Definitions of Industrial Robot, Type and Classification of Robots, Asimov's laws of robotics, Robot configurations, Robot Components, Robot Degrees of Freedom, Work volume and work envelope, Robot Joints and symbols, Robot Coordinates, Robot Reference Frames, Resolution, accuracy and precision of Robot, Work cell control.

UNIT – II

Robot Drive systems

Pneumatic Drives, Hydraulic Drives, Mechanical Drives, Electrical Drives-D.C. Servo Motors, Stepper Motors, BLDC Motors -Salient Features, Applications and Comparison of all these Drives, Micro actuators, selection of drive, Power transmission systems for robot.

UNIT – III

Mathematical Modeling of Robot

Direct Kinematics, Co-ordinate and vector transformation using matrices, Rotation matrix, Inverse Transformations, Composite Rotation matrix, Homogenous Transformations, Robotic Manipulator Joint Co-ordinate System, inverse kinematics of two joints, DH Parameters, Jacobian Transformation in Robotic Manipulation

UNIT – IV

Introduction to Sensors

Transducers and sensors, Sensors in robotics, Principles and applications of the following types of sensors- Proximity Sensors, Photo Electric Sensors, Position sensors – Piezo Electric Sensor, LVDT, Touch Sensors, Force and torque sensors.

Practice :

1. Application of IR Proximity Sensor
2. Application of Ultrasonic Proximity Sensor
3. Application of Touch Sensor

UNIT – V

Role of Microcontroller in Robotics

Introduction to microcontrollers, Microcontrollers and microprocessors, Introduction to Arduino, Types of Arduino boards, Programming basics: Structure of a code

Practice :

1. Blink On-Board LED
2. Blink LED(S)
3. Change Brightness of LEDS
4. Control of Dc Motors (Direction and Speed)
5. Study and Control of Servo Motor Using Arduino
6. Study and Control of Bipolar Stepper Motor Using Arduino

Text Books:

1. Robotics: Modelling, Planning and Control, Bruno Siciliano et al., Springer London Ltd, 1st edition. 2009,ISBN : 9781846286414.
2. Introduction to Robotics: Analysis, Control, Applications, Saeed B. Niku, Wiley, 2019,3rd edition, ISBN : 9781119527626.

Reference Books:

1. Robotics: Control, Sensing, Vision, and Intelligence, C.S.G. Lee et al., CRC Press, 2018, ISBN : 9780071004213.
2. Robotics: Theory and Industrial Applications, Larry Ross et al.,Wiley-IEEE Press,2nd edition,2010, ISBN-13 : 9781605253213.

Web Links:

1. https://nptel.ac.in/courses/107106090
2. https://www.coursera.org/specializations/introduction-robotics-webots
3. https://nptel.ac.in/courses/108105102

Programming for Robotics

Course Code: 241ME025	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Explain the installation procedure and programming structure of Python
- **CO2:** Demonstrate the ability to create, manipulate, and apply various data structures and algorithms, including arrays and lists.
- **CO3:** Utilize data structures and algorithms in engineering applications, incorporating advanced Python features such as list comprehensions and decorators.
- **CO4:** Manipulate multi-dimensional arrays using numpy and perform complex numerical operations relevant to engineering tasks
- **CO5:** Conduct data analysis and create visualizations using pandas and matplotlib to derive insights from data.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2			3			1	1		2
CO2	3	3			3			1	1		2
CO3	3	3	1		3			1	1		2
CO4	3	2	1	2	3			1	1		2
CO5	3	2	1	2	3			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Introduction to Python (Basics)

Overview of Python language, Basic syntax and data types, Control structures (loops, conditionals). Installation of PYTHON, Installation Of Libraries

Practice:

1. Write a program that takes users input and prints the type of input and also creates loops to calculate the factorial of numbers

UNIT – II

Data Structures & Algorithms

Arrays and Lists in Python, Creating and manipulating arrays/lists, Array slicing and indexing, Array operations (concatenation, repetition), Array Manipulation Techniques, Sorting arrays, Searching arrays, Filtering and selecting array elements. Array Algorithms, Linear search and binary search algorithms, Sorting algorithms (selection sort, bubble sort, merge sort),

Practice:

1. Implement and compare the performance of sorting techniques.

UNIT – III

Applications of DSA

Applications of Array Manipulation in Engineering. List Comprehensions, Multiple Function Arguments, Regular Expressions, Exception Handling, Sets, Serialization, Partial functions, Code Introspection, Closures, Decorators, Map, Filter, Reduce.

Practice:

1. Write a function that takes variable number of arguments and returns their sum ,

UNIT – IV

Array Manipulation

Multi-dimensional Arrays, Introduction to multi-dimensional arrays, manipulating multi-dimensional arrays, Applications of multi-dimensional arrays in engineering, numpy operations.

Practice:

1. Create a program to use numpy to perform matrix addition, subtraction and multiplication
2. Perfom any statical operations like mean/median/standard deviation on numpy arrays

UNIT – V

Data Analysis and Visualization

Introduction to Pandas library and its importance in data analysis, installation and understanding of Series and DataFrame; Series creation and manipulation, DataFrame creation, slicing and filtering; data cleaning techniques, transformation methods, descriptive statistics, aggregation ,visualization using Pandas' built-in plotting functions.Visualization with Matplotlib.

Practice:

1. Install pandas and create series and data frame objects, perform data transformation like normalization , scaling.
2. Create more complex visualizations using Matplotlib: scatter plots, pie charts.

Text Books:

1. Data Structure and Algorithmic Thinking with Python, Narasimha Karumanchi, CareerMonk Publications, 1st edition,2015, ISBN : 9788192107592.
2. Fundamentals of Python First Programs, Kenneth. A. Lambert, Cengage, 2nd edition,2019, ISBN : 9789353502898.

Reference Books:

1. Introduction to Python Programming, Gowrishankar.S, Veena A, CRC Press, 2019, ISBN : 9780367410179.
2. Introduction to Programming Using Python, Y. Daniel Liang, Pearson, 1st edition,2017, ISBN : 9789332551848.

Web Links:

1. https://nptel.ac.in/courses/106106182
2. https://www.tutorialspoint.com/python/index.htm

Digital Manufacturing

Course Code: 241ME026	L	T	P	C
	3	0	0	3

Course Outcomes:

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

CO1: Explain the concept and historical evolution of Digital Manufacturing, including Industry 4.0 and Cyber-Physical Systems.

CO2: Apply various CAD modeling techniques to create three-dimensional models, including parametric and assembly modeling.

CO3: Assess the need and process of Reverse Engineering, and develop geometric models using appropriate hardware and software tools.

CO4: Utilize Computer-Aided Manufacturing (CAM) tools to model components, select machines and tools, generate tool paths, simulate processes, and perform post-processing.

CO5: Evaluate the processes and technologies involved in Additive Manufacturing, including material selection, process planning, and post-processing techniques.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2			2						1
CO2	3	2			2						2
CO3	3	3	2	2	2						1
CO4	3	3	2	1	3						1
CO5	2	2	2	2	3						1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		
CO2	1	
CO3	1	
CO4		
CO5	1	

UNIT – I

Introduction to Digital Manufacturing: Definition of digital manufacturing, Historical perspective on industrial production and outlook, Industrial Revolutions, Industry 4.0, Cyber physical system, Factory of the future, Operation Mode and Architecture of Digital Manufacturing System.

UNIT – II

CAD Modeling: Design process and role of CAD, Types and applications of design models, Three-dimensional modelling schemes, Wire frames and surface representation schemes, Solid modelling - Parametric modelling, Assembly modelling.

UNIT – III

Reverse Engineering: Need, Reverse engineering process, reverse engineering hardware and software, Geometric model development from physical objects using 3D Scanning or manual measurements.

UNIT – IV

Computer Aided Manufacturing: Component modeling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing.

UNIT – V

Additive Manufacturing for Digital Transformation: Introduction to additive manufacturing, Additive manufacturing process chain, Material selection, Manufacturing, Post processing, Additive manufacturing technologies and processes, Vat photo polymerization, fused filament fabrication, Material jetting, Sheet lamination, Powder bed fusion, Binder jetting, Planning and slicing additive manufacturing software.

Text Books:

1. Fundamentals of Digital Manufacturing Science, Zude Zhou, Shane Xie, Dejun Chen, Springer,2013, ISBN : 9781447127147.
2. CAD/CAM - Theory and Practice, Ibrahim Zeid and Sivasubramanian R, Tata McGraw Hill Education,2nd edition,2009, ISBN : 9780070151345.

Reference Books:

1. Reverse Engineering An Industrial Perspective, Vinesh Raja and Kiran J Fernandes, Springer, 1st edition,2010, ISBN : 9781849966603.
2. Rapid Prototyping: Principles and Applications, C. K. Chua, L. F. Leong, C.S Lim, World Scientific Publications, 3rd edition,2010, ISBN : 9789812778987.

Web Links:

1. https://nptel.ac.in/courses/110106146
2. https://www.coursera.org/learn/introduction-digital-manufacturing-fusion-360
3. https://onlinecourses.swayam2.ac.in/nt2.4_ed17/preview

Advanced Fluid Power & Control Systems

Course Code: 241ME027	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Explain the principles and terminology of fluid power systems and hydraulic fundamentals.
- **CO2:** Develop skills in PLC programming and design of PLC-based control circuits.
- **CO3:** Explain the functioning of hydraulic actuators and control components
- **CO4:** Design and implement pneumatic circuits and systems, integrating electrical drives for enhanced control.
- **CO5** Explain the principles and applications of electrical drives and compact drives

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	1		1			1	1		1
CO2	3	2	2		1			1	1		2
CO3	3	2	2	1	1			1	1		1
CO4	3	2	2	1	2			1	1		2
CO5	3	2	2		2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		1
CO2	1	
CO3	1	
CO4	1	
CO5		

UNIT – I

Fundamentals of Fluid Power and Hydraulics:

Introduction to Fluid Power: Definition and significance of fluid power systems, Advantages and applications in various industries.

Basics of Hydraulics: Pascal's Law, Explanation and applications, Principles of fluid flow: Laminar and turbulent flow, Friction loss in hydraulic systems.

Sources of Hydraulic Power: Pumping Theory: Basic principles and mechanisms. Classification of Pumps: Types (gear, vane, piston pumps) and their applications, Construction and Working of Hydraulic Pumps, Design considerations, advantages, and disadvantages, Performance characteristics and selection criteria for pumps.

Practice:

1. To demonstrate Pascal's Law and the principles of fluid flow

UNIT – II

Programmable Logic Controllers (PLCs)

Introduction to PLCs: Basic structure and components, Principle of operation.

PLC Programming: Introduction to programming languages (Ladder logic, Function block diagram), Concept of ladder diagram and programming techniques, Latching in PLCs.

Logic Gates Using PLCs: Implementation of basic logic gates (AND, OR NOT) using PLCs. Complex logic circuits and their applications.

PLC-Based Electro-Pneumatic Circuits: Design and implementation of electro-pneumatic control circuits.

Practice:

1. To understand the basics of PLC programming and implement simple logic gates

UNIT – III

Hydraulic Actuators and Control Components

Hydraulic Actuators: Types and construction of hydraulic cylinders. Applications of different types of cylinders. Hydraulic cushioning mechanisms, Hydraulic motors: Types and applications.

Control Components: Direction control valves: Types, construction, and operation, Flow control valves: Types and applications, Pressure control valves: Types and mechanisms, Servo and proportional valves: Working principles and applications.

Hydraulic System Accessories: Reservoirs, pressure switches, and their roles, Introduction to Fluid Power ANSI Symbols.

Practice:

1. To study the construction and operation of hydraulic cylinders and motors.
2. To understand the operation of different types of control valves.

UNIT – IV

Pneumatic Circuits and Systems

Properties of Air: Overview of air properties and perfect gas laws.

Pneumatic Components: Compressors: Types and working principles, Filters, regulators, lubricators, and mufflers: Functions and applications, Air control valves and quick exhaust valves.

Pneumatic Actuators: Types and applications in various systems.

Design of Pneumatic Circuits: Cascade method for circuit design, Electro-pneumatic systems: Components and design principles, Ladder diagrams for pneumatic control.

Electro-Pneumatic Logic Circuits: Design and implementation, Practical problems

Practice :

1. To design and test basic pneumatic circuits.
2. To design and implement electro-pneumatic control system

UNIT – V

Electrical Drives

Working Principle of Servo Drives: Introduction to Servo drives and their applications, Harmonic drives and their advantages.

Compact Drives and Variable Frequency Drives (VFDs: Working principles and applications in industry.

Integration with Fluid Power Systems: Combining electrical drives with hydraulic and pneumatic systems for enhanced control.

Practice :

1. To implement and calibrate PID control in a hydraulic or pneumatic system

Text Books:

1. Fluid Power Engineering, M. Galal Rabie, McGraw-Hill Professional,2009, ISBN : 9780071622462.
2. Programmable Logic Controllers, Frank D. Petruzella, McGraw-Hill Education, 4th edition,2010, ISBN : 9780073510880.

Reference Books:

1. Introduction to Hydraulics for Industry Professionals, Medhat Khalil, Compudraulic LLC,2016, ISBN : 9780692622360.
2. Pneumatic Systems: Principles and Maintenance, S.R. Majumdar, McGraw Hill Education, 1st edition,2017, ISBN : 9780074602317.

Web Links:

1. https://nptel.ac.in/courses/112106300
2. https://www.coursera.org/lecture/fluid-power/hydraulics-and-pneumatics-SD8dv

Robotic Mobility Systems

Course Code: 241ME028	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Explain the principles of kinematic and dynamic analysis of robot manipulators
- **CO2:** Apply techniques to control both the position and orientation of the tool in three-dimensional space
- **CO3:** Analyze the relationship between joint variables and the position/orientation of the tool
- **CO4:** Create plans for guiding the tool along trajectories to execute specific tasks effectively
- **CO5** Evaluate methods for precisely controlling high-speed motion within the system

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	2	1				1	1		
CO2	2	2	2	2	2			1	1		
CO3	2	3	2	1	1			1	1		
CO4	2	2	2	2	1			1	1		
CO5	2	2	2	2	2			1	1		

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Introduction

Introduction, position and orientation of objects, objects coordinate frame Rotation matrix,Euler angles Roll, pitch and yaw coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames and Rotations, Homogeneous coordinates.

Practice:

1. Installation of MATLAB and implementing the basic exercise to execute the position, orientation of objects.
2. Implementation of homogeneous transformations

UNIT – II

Direct Kinematics

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.

Practice:

1. Implementation of basic exercise in matlab to demonstrate the DH Convention
2. Implementation of basic exercise in matlab to demonstrate kinematic anaylsis

UNIT – III

Inverse Kinematics

The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, Articulated robot.

Practice:

1. Practice exercises solving the inverse kinematics

UNIT – IV

Workspace Analysis and Trajectory Planning

Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique.

Practice:

1. Practice exercises to implement various motions associated like continuous path motion, interpolated motion, straight line motion, etc.

UNIT – V

Manipulator Dynamics

Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity and Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange - Euler formulation, Example problems.

Practice:

1. Basic exercise to implement Lagrange's equation to explore the effects of forces and dynamic modelling of newton Euler and Lagrange formulations.

Text Books:

1. Robotics Engineering an Integrated Approach, Richard D. Klafter, A. Thomas, Chri Elewski, Michael Negin, PHI Learning, ISBN: 981-240-625-5
2. Engineering foundation of Robotics, Francis N. Nagy Andras Siegler, Prentice Hall Inc ISBN: 978-0132788052

Reference Books:

1. Industrial Robotics, Bernard Hodges, Jaico Publishing house, ISBN: 978-0434907823
2. Foundations of Robotics Analysis and Control, Tsuneo Yohikwa, MIT Press, ISBN: 9780262514583
3. Introduction to Robotics Mechanics and Control, John J. Craig, Pearson, ISBN: 978-0201543612

Web Links:

1. https://www.ros.org/
2. https://www.classcentral.com/course/robotics-delft-university-of-technology-hello-rea-11555
3. https://www.classcentral.com/course/udemy-ros-essentials-68029

Control of Robotic System

Course Code: 241ME029	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Explain MATLAB fundamentals for practical application.
- **CO2:** Comprehend transfer functions and signal flow graphs for linear system analysis.
- **CO3:** Explain time and frequency responses, along with state-space models and their connection to frequency domains.
- **CO4:** Comprehend dynamic system modeling techniques.
- **CO5:** Explain stability concepts for system analysis.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	1	1	1				1	1		1
CO2	2	2	2	1	2			1	1		1
CO3	2	2	2	1	2			1	1		1
CO4	2	2	2	1	2			1	1		1
CO5	2	2	2	2	2			1	1		1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

MATLAB:

MATLAB for Control system Basics, Language Fundamentals, Mathematical Operations, Graphics and Programming

Practice:

1. Installation of MatLab and getting familiarized with the basic environment.
2. Creating variables by exploring built-in functions.

UNIT – II

Basics of Control, Control Systems:

Types of Controllers, Introduction to closed loop control, Differential Equations, Transfer functions, Block diagrams, Signal Flow Graph.

Practice:

1. Perform exercises related different types of controllers
    a. Closed loop control
    b. Differential equations
    c. Transfer functions
    d. Block diagrams

UNIT – III

Time Response and Frequency Response

Time Response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Frequency response, Bode Plots, polar plots, Nyquist Plots.

Practice:

1. Implementing the time response analysis , root locus design and understanding of frequency response using bode plots, polar plots, etc.

UNIT – IV

Linear Control System:

Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint.

Practice:

1. Implementing exercises related to controllability, observability and design basic controllers for linear systems

UNIT – V

Non-Linear Control System:

Common physical non-linear system, phase plane method, system analysis using phase plane methods, stability of non-linear system, Lyapunov's stability criterion, the control problems in manipulators.

Practice:

1. Explore the stability analysis using Lyapunov's stability criterion

Text Books:

1. Control Systems, M. Gopal, McGraw-Hill, 4th edition,2012, ISBN : 9780071333269.
2. Modern Control Engineering, K. Ogata, Prentice Hall India, 5th edition,2015, ISBN : 9789332550162.
3. Robot Modeling and Control, M. Spong, M. Vidyasagar, S. Hutchinson, Wiley & Sons, 1st edition,2005, ISBN : 9780471649908.

Reference Books:

1. Introduction to Robotics: Mechanics and Control, J. J. Craig, Addison-Wesley, 3rd edition,2004, ISBN : 9780201543612.
2. Introduction to Robotics, S. K. Saha, TATA McGraw Hills Education,2008, ISBN : 9780070140011.
3. Linear Systems: Optimal and Robust Control, Alok Sinha, Taylor & Francis, 1st edition,2007, ISBN : 9780849392177.

Web Links:

1. https://matlabacademy.mathworks.com/details/matlab-onramp/gettingstarted
2. https://nptel.ac.in/courses/103106118
3. https://nptel.ac.in/courses/107106081

AI for Robotics

Course Code: 241ME030	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Explain machine learning principles and terminology.
- **CO2:** Explain supervised learning algorithms
- **CO3:** Develop skills for applying unsupervised learning
- **CO4:** Analyze advanced machine learning techniques and their applications.
- **CO5:** Apply practical skills in deep learning

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2			1						2
CO2	2	2			1			1	1		2
CO3	2	2	2		2			1	1		2
CO4	2	2	2	2	2			1	1		2
CO5	2	2	2	2	2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Foundations of Machine Learning

Introduction to Machine Learning: Definition, significance, differences from traditional programming. Key Concepts and Terminology: Dataset, features, labels, model, training, testing, overfitting, underfitting. Basic Data Handling: Data collection, preprocessing, scaling, handling missing data. Tools and Libraries: Python, Jupyter, NumPy, Pandas, Scikit-learn, TensorFlow, PyTorch.

UNIT – II

Supervised Learning

Regression: Linear regression, multiple regression, evaluation metrics (MSE, RMSE, R^2). Classification: Logistic Regression, k-NN, SVM, Decision Trees, Random Forests, Naive Bayes. Model Evaluation: Cross-validation, bias-variance tradeoff, hyperparameter tuning.

Practice:

1. Train a robot to classify and recognize objects using image data.

UNIT – III

Unsupervised Learning

Clustering: k-Means, Hierarchical Clustering, DBSCAN, Gaussian Mixture Models.

Dimensionality Reduction: PCA, t-SNE, LDA.

Practice:

1. Analyze customer data using clustering techniques.

UNIT – IV

Advanced Topics in Machine Learning

Neural Networks: Architecture, layers, activation functions, backpropagation. Model Optimization: Gradient descent, regularization (L1, L2, dropout), learning rate tuning. Ensemble Methods: Bagging, Boosting, Random Forests, XGBoost.

Practice:

1. Optimize a neural network for image classification.

UNIT – V

Basics of Deep Learning

Neural Networks: Structure, forward/backpropagation. Convolutional Neural Networks (CNNs): Convolution and pooling layers, image processing. Recurrent Neural Networks (RNNs): Sequential data, LSTM, GRU

Practice:

1. Implement a CNN for image recognition tasks.

Text Books:

1. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer,1st edition,2009, ISBN : 9781493938438.
2. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, Aurélien Géron, O'Reilly Media, 2nd Edition, 2019, ISBN : 9781492032649.

Reference Books:

1. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, ISBN : 9780262035613.
2. Python Machine Learning, Sebastian Raschka and Vahid Mirjalili, Packt Publishing, 3rd Edition, 2019, ISBN : 9781789955750.
3. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, the MIT Press, ISBN : 9780262018029.

Web Links:

1. https://skillsbuild.org/students/course-catalog/artificial-intelligence
2. https://www.coursera.org/learn/introduction-to-aipervised2014a.pdf (umass.edu)
3. https://nptel.ac.in/courses/106105077

Robotic Operating System

Course Code: 241ME031	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Utilize Ubuntu and Linux operating systems for applications
- **CO2:** Use C++ for programming for Robot Operating System
- **CO3:** Use Python for programming for Robot Operating System
- **CO4:** Install and explain architectural aspects of ROS
- **CO5:** Create ROS workspace and package for Robot programing

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	1	1	1	2			1	1		1
CO2	2	2	1	2	2			1	1		2
CO3	2	2	1	2	2			1	1		2
CO4	2	2	1	2	2			1	1		2
CO5	2	2	2		2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		
CO2		
CO3		
CO4		
CO5	1	

UNIT – I

UBUNTU Linux for Robotics

GNU/Linux - Installing Ubuntu - Installing VirtualBox - Playing with Ubuntu – Useful Ubuntu Applications – Shell Commands.

Practice:

1. Installing of required Tools and packages like Ubuntu, Virtualbox and some shell commands.

UNIT – II

C++ for Robotics Programming

Getting Started with C++ C/C++ in Ubuntu Linux - Learning OOP Concepts – Building a C++ Project.

Practice:

1. Writing programs to implement the basics of C++ programming to run in Ubuntu

UNIT – III

Python for Robotics Programming

Python - Timeline: The Python Language — Python in Ubuntu Linux - Introduction to Python Interpreter – Installing Python on Ubuntu — Verifying Python Installation - Writing First Code — Understanding Python Basics.

Practice:

1. Setting up Python on Ubuntu platform executing some basic programs that covers the core fundamentals of python

UNIT – IV

KICK-Starting Robot Programming Using ROS

Robot Programming - The ROS Equation - Robot Programming Before and After ROS Installing ROS - Robots and Sensors Supporting ROS - Popular ROS Computing Platforms - ROS Architecture and Concepts.

Practice:

1. Installing ROS on ubuntu
2. Exploring ROS to understand the various architectural functions like nodes, topics, messages, services etc of robots and sensors compatibility

UNIT – V

Programming with ROS

Programming Using ROS - Creating a ROS Workspace and Package - Using ROS Client Libraries – Programming Embedded Boards.

Practice:

1. Creating workspace and working with different packages using ROS

Text Books:

1. Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy, Lentin Joseph, Apress,1st edition,2018, ISBN : 9781484234044.

Reference Books:

1. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernández, Packt Publishing Ltd,2013, ISBN : 9781782161448.

2. Robot Operating System (ROS): The Complete Reference, Volume 3, Anis Koubaa, Springer,1st edition,2019, ISBN : 9783319915890.

3. Programming Robots With ROS: A Practical Introduction To The Robot Operating System, Morgan Quigley, Shroff Publishers & Distributors Pvt Ltd, 1st edition,2015, ISBN-9781449323899.

Web Links:

1. https://www.ros.org/

2. https://www.classcentral.com/course/robotics-delft-university-of-technology-hello-rea-11555

3. https://www.classcentral.com/course/udemy-ros-essentials-68029

Advanced Robotic Operating System

Course Code: 241ME032	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Apply advanced ROS setup and administration techniques
- **CO2:** Create and optimize complex ROS nodes for real-time data processing.
- **CO3:** Integrate ROS nodes with various robotics hardware
- **CO4:** Utilize intermediate ROS functionalities
- **CO5:** Implement advanced ROS applications

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	1	1		2			1	1		1
CO2	2	2	2		2			1	1		2
CO3	2	2	2		2			1	1		2
CO4	2	2	2		2			1	1		2
CO5	2	2	2		2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		
CO2		
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Advanced ROS Setup and Administration

Set up multiple ROS environments, Optimize ROS installation for different hardware platforms, Network Configuration for ROS: Configure ROS for networked robots, Set up ROS Master URI and multi master setups, ROS Security and Permissions Management: Implement security measures in ROS, Manage permissions and access control.

Practice:

1. Setting up and configuring a ROS environment with multiple masters and implementing basic security measures.

UNIT – II

Advanced ROS Programming in C++

Writing Advanced ROS Nodes in C++, Develop complex nodes with advanced functionality, Optimize nodes for performance, Implementing ROS Services and Actions in C++, Create and manage ROS services and actions Implement synchronous and asynchronous communication, Real-time Data Processing in ROS with C++, Handle real-time data streams, Optimize data processing for latency and throughput ROS Nodelets for Efficient Communication, Integration with Robotics Hardware in C++, Interface with sensors and actuators, Develop hardware drivers in C++ .

Practice:

1. Developing and optimizing a complex ROS node in C++ for real-time data processing.

UNIT – III

Advanced ROS Programming in Python

Writing Advanced ROS Nodes in Python: Develop complex nodes with advanced functionality, Optimize nodes for performance, Implementing ROS Services and Actions in Python: Create and manage ROS services and actions, Implement synchronous and asynchronous communication, Real-time Data Processing in ROS with Python: Handle real-time data streams, Optimize data processing for latency and throughput, Using Python for ROS-based Data Analysis and Visualization: Analyze and visualize ROS data, Use Python libraries for data processing (e.g., NumPy, Matplotlib), Integration with Robotics Hardware in Python: Interface with sensors and actuators, Develop hardware drivers in Python

Practice:

1. Creating and optimizing a complex ROS node in Python for data analysis and visualization.

UNIT – IV

Intermediate ROS Functionalities

Using ROS Parameters and Parameter Server: Configure ROS parameters, Use the parameter server for dynamic configuration, Dynamic Reconfiguration of ROS Nodes: Implement dynamic reconfiguration, Use the dynamic reconfigure package, Implementing ROS Actions: Set up and use ROS actions, Handle action goals, feedback, and results, ROS Bag for Data Recording and Playback: Record and playback ROS topics, Analyze recorded data, Visualize robot states and sensor data ,Use plugins for advanced visualization.

Practice:

1. Implementing dynamic reconfiguration and using ROS bags for recording and analyzing robot sensor data.

UNIT – V

Advanced ROS Applications

ROS Navigation Stack: Implement autonomous navigation, Configure and use SLAM (Simultaneous Localization and Mapping), ROS for Manipulation: Plan and execute robotic arm movements, Use motion planning algorithms, Use cloud-based services for advanced robotics applications.

Real-time Robot Control with ROS: Develop real-time control applications

Practice:

1. Implementing an autonomous navigation system using the ROS navigation stack and SLAM.

Text Books:

1. Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy, Lentin Joseph, Apress,1ST edition,2018, ISB : 9781484234044.
2. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernández, Packt Publishing Ltd,2013, ISBN : 9781782161448.

Reference Books:

1. Robot Operating System (ROS): The Complete Reference, Volume 3, Anis Koubaa, Springer,1st edition,2019, ISBN : 9783319915890.
2. Programming Robots With ROS: A Practical Introduction To The Robot Operating System, Morgan Quigley, Shroff Publishers & Distributors Pvt Ltd,1st edition,2015, ISBN : 9781449323899.

Web Links:

1. https://www.ros.org/
2. https://www.classcentral.com/course/robotics-delft-university-of-technology-hello-rea-11555
3. https://www.classcentral.com/course/udemy-ros-essentials-68029

Field & Service Robotics

Course Code: 241ME033	L	T	P	C
	2	0	1	3

Course Outcomes:

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

- **CO1:** Evaluate the historical development and assess the importance of service robotics.
- **CO2:** Identifying and resolve localization challenges using appropriate techniques.
- **CO3:** Acquire the necessary skills to employ path planning methodologies proficiently
- **CO4:** Develop competency in utilizing various navigation techniques effectively.
- **CO5:** Implement the efficacy of obstacle avoidance techniques in service robotics.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	1	1	1			1	1		1
CO2	2	2	2	2	2			1	1		2
CO3	2	2	2	2	2			1	1		2
CO4	2	2	2	2	2			1	1		2
CO5	2	2	2	2	2			1	1		2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Introduction

History of service robotics – Present status and future trends – Need for service robots - applications- examples and Specifications of service and field Robots. Non-Conventional Industrial robots.

Practice:

1. Demonstrate the Specifications and working of Service and Field Robots

UNIT – II

Localization

Introduction-Challenges of Localization- Map Representation- Probabilistic Map based Localization- Monte-Carlo localization- Landmark based navigation-Globally unique localization- Positioning beacon systems- Route based localization.

Practice:

1. Design and implement a system where a robot navigates using landmarks (e.g., QR codes, visual markers) placed in its environment.

UNIT – III

Planning and Navigation

Introduction-Path planning overview- Road map path planning- Cell decomposition path planning- Potential field path planning-Obstacle avoidance - Case studies: tiered robot architectures.

Practice:

1. Implement a simple grid-based map representation for a robot's environment and develop algorithms for updating and querying the map.

UNIT – IV

Navigation Techniques and Algorithms

Sensor-based navigation, Dead reckoning, Beacon-based navigation, Landmark-based navigation

Practice:

1. Develop a navigation system that utilizes sensor data (e.g., LiDAR, cameras) for localization and obstacle avoidance.

UNIT – V

Obstacle Avoidance Techniques

Potential field method, Virtual force field method, Artificial potential fields method

Optimal Path Planning Techniques and Trajectory Planning

Dijkstra's algorithm, M algorithm, Probabilistic Road map method.

Practice:

1. Implement Dijkstra's algorithm to solve a maze.
2. Implement A* to solve a maze.

Text Books:

1. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, Bradford Company Scituate, MIT Press,2nd edition,2011, ISBN : 9780262015356.
2. The Future of Humanoid Robots: Research and Applications, Riadh Ziaer, Intech Publications,2014, ISBN : 9789533079516.

Reference Books:

1. Robotics Engineering – An Integrated Approach, Richard D. Klafter, Thomas A. Chmielewski, Michael Negin, Eastern Economy Edition, Prentice Hall of India Pvt. Ltd, ISBN : 9788120308428.
2. Field and Service Robotics, Alonzo Kelly, Karl Iagnemma, Andrew Howard, Springer,1st edition,2016, ISBN : 9783662519165.

Web Links:

1. https://docs.ros.org/en/melodic/api/robot_localization/html/index.html
2. https://wiki.ros.org/navigation/Tutorials/Writing%20A%20Global%20Path%20Planner%20As%20Plugin%20in%20ROS
3. https://wiki.ros.org/teb_local_planner/Tutorials/Obstacle%20Avoidance%20and%20Robot%20Footprint%20Model

Minor Stream: Thermal Engineering

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME035	Power Plant Engineering	FC	2			2	50	50	100	-
241ME036	Sustainable Energy Systems	FC	3			3	50	50	100	-
241ME037	Solar Energy Systems	FC	3			3	50	50	100	-
241ME038	Alternative Fuels for IC engines	IC	3			3	50	50	100	ICE
241ME039	Fuel Cell Technology	IC	3			3	50	50	100	ICE
241ME040	Refrigeration & Air Conditioning	IC	2	1		3	50	50	100	ETD
241ME041	Hydraulic Machinery & Systems	IC	3			3	50	50	100	FMHM
241ME042	Cryogenic Engineering	AC	3			3	50	50	100	R&AC
241ME044	Energy Storage Systems	AC	3			3	50	50	100	BEEE
241ME045	Gas Dynamics & Jet Propulsion	AC	2	1		3	50	50	100	HPE
241ME046	Computational Fluid Dynamics	AC	2	1		3	50	50	100	HT, FMHM
	Total		**29**	**3**		**32**				

Power Plant Engineering

Course Code: 241ME035

L	T	P	C
2	0	0	2

Course Outcomes:

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

CO1: Explain the sources of energy, various components and layouts of steam power plant.
CO2: Explain the layout, construction and working of the diesel and gas power plants.
CO3: Describe the working of hydroelectric power plant and hydrauic turbines
CO4: Explain the working of nuclear power plants.
CO5: Describe the load curves and method to reduce the pollutants

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3				2	2					
CO2	3										
CO3	3					2					
CO4	3										
CO5	3	2									

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

UNIT – I

Introduction to Power Plants :Classification power plants - Current scenario of national and global power generation, Carbon capture and storage.

Steam Power Plant: Site selection, Components and Layouts - Coal handling and preparation - Combustion equipment and firing methods - Mechanical stokers - Pulverized coal firing systems - Cyclone furnace – Fuel & Ash handling systems- Dust collection – Draft Systems – Cooling Towers.

UNIT – II

Diesel Power Plant: Components & layout – working, Different systems – Fuel system, lubrication system, Air intake system, Exhaust system, cooling system. Starting system.

Gas Power Plant: Components and Layout, Open and closed cycles - Intercooling - Reheating and Regenerating – hydrogen fuelled GTs, Hydrogen-fired GTs .

UNIT – III

Hydroelectric Power Plant:

Site selection, Components and Layout, Estimation of power potential, Classification of Hydro - electric power plants- Selection of turbines- Governing of turbines.

UNIT – IV

Nuclear Power Plant:

Site selection, Principles of nuclear energy - Energy from nuclear reactions - Components and Layout, Thermal reactors: Boiling water reactor - Pressurized water reactors and heavy water reactors - Boiling Water Reactor - Gas cooled reactor - High temperature gas cooled reactor - Fast breeder reactor - biological effects of nuclear radiation, - Nuclear waste disposal.

UNIT – V

Load Curve & Pollution Control:

Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants. O_2 and CO_2 measurements.

Text Books:

1. Power Plant Technology, El-Wakil M.M, Tata McGraw-Hill Publishing, 1st Edition,2017, ISBN : 9780070702448.
2. Power Plant Engineering, P. K. Nag, Tata McGraw-Hill Publishing Company Ltd, 4th Edition,2017, ISBN : 9789339204044.

Reference Books:

1. Power Plant Engineering, Hegde R.K, , Pearson India Education services (P) Ltd., 1st edition,2015, ISBN : 9789332534100.
2. Power Plant Engineering, G.R.Nagpal, Khanna Publishers, 16th Edition, ISBN : 9788174093097.

Web Links:

1. https://nptel.ac.in/courses/108105058/8
2. https://ocw.mit.edu/courses/22-312-engineering-of-nuclear-reactors-fall-2015/download/
3. https://archive.nptel.ac.in/courses/112/107/112107291/

Sustainable Energy Systems

Course Code: 241ME036	L	T	P	C
	3	0	0	3

Course Outcomes:

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

CO1: Demonstrate the various components of solar thermal energy systems.
CO2: Describe the working of Wind turbines.
CO3: Explain the principle and working of Biomass and Geothermal Energy systems
CO4: Explain the Ocean, Tidal, Wave and hydro energy conversion systems.
CO5: Illustrate working of hybrid energy systems.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2					3					
CO2	2					3					
CO3	2					3					
CO4	2					3					
CO5	2					3					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		1
CO2		1
CO3		1
CO4		1
CO5		1

UNIT – I

Introduction to Renewable energy sources: Energy demand and availability, energy crisis, renewable and non-renewable energy resources, environmental impact of conventional energy usage.

Solar Energy: Overview of the fundamental physics of solar radiation. Solar energy collectors.

Solar energy storage: Stratified storage, well mixed storage, comparison, Hot water system, solar ponds, non-convective solar pond, extraction of thermal energy and application of solar ponds.

Solar PV systems and its applications. Solar cell, module, and array.

UNIT – II

Wind Energy: Wind data and energy estimation – Betz limit - Site selection for windfarms. Horizontal and vertical axis wind mills, Wind farms- offshore, Onshore, various methods of control, and Environmental issues - Applications

UNIT – III

Biomass: Bio-resources, Conversion process, Biomass gasifier - Types of biomass gasifiers, Biodiesel production – Ethanol production -Applications.

Geothermal Energy: Origin and types of geothermal energy and utilisation, Power generation from Geothermal energy, Environmental impact.

UNIT – IV

Ocean, Wave & Tidal Energy: Introduction - Resource Assessment - Power generation through OTEC systems. Wave and Tidal energy- Working principle, Availability, and energy conversion systems.

Mini & Micro Hydropower: Introduction, Power from water, System components of Mini and Micro Hydropower, Micro Hydropower plant in India, Potential Hydropower plant projects identified in India.

UNIT – V

Hybrid Energy Systems: Systems for processes and power applications – solar – wind – Biomass hybrid technologies

Fuel cell: Working principle- types - construction and applications. Solar – Fuel cell hybrid systems.

Text Books:

1. Renewable Energy: Power for a Sustainable Future, Boyle, G, Oxford University Press, 3rd Edition, ISBN : 9780199681273.
2. Non-Conventional Energy Sources, G.D.Rai, Khanna Publishers, 6th edition, ISBN : 9788174090737.

Reference Books:

1. Renewable Energy Resources, John Twidell, Tony Weir, and Anthony D. Weir,Taylor & Francis,3rd edition, ISBN : 9780415584388.
2. Non-Conventional Energy Resources, B H Khan, TMH Publishers, 3rd Edition, ISBN : 9789352601882.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc22_ch27/preview
2. https://www.energy.gov/eere/renewable-energy

Solar Energy Systems

Course Code: 241ME037	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the concept of solar radiation and its measurement
- **CO2:** Describe the working principle of different types of collectors.
- **CO3:** Explain the various solar thermal energy technologies and their applications
- **CO4:** Analyze the various solar PV cell materials and conversion techniques.
- **CO5:** Apply solar passive building techniques for cooling and heating applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	1				3					
CO2	2	1				3					
CO3	2	1				3					
CO4	2	1				3					
CO5	2	1				3					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		1
CO2		1
CO3		1
CO4		1
CO5		1

UNIT – I

Solar Radiation and its measurement: Solar angles, Sun path diagrams, Radiation, extraterrestrial characteristics, Solar energy measuring instruments: Pyranometer, Pyrheliometer, Sunshine recorder. Estimation of average solar radiation and estimation on horizontal and tilted surfaces

UNIT – II

Solar Collectors for Industrial process heat: Flat plate collector, Materials for flat plate collector and their properties, classification, evacuated tubular collectors, concentrator collectors, tracking systems, compound parabolic concentrators, parabolic trough concentrators, concentrators with point focus, Heliostats.

UNIT – III

Solar Thermal Technologies: Working principle, types, design, and operation, Solar heating and cooling systems, Thermal Energy storage systems, Solar Desalination, Solar cooker, Solar Pond, Solar drying, Solar chimney, Solar water disinfection (SODIS), Solar furnaces.

UNIT – IV

Solar Cells: Semiconductor materials, Doping, PN junction and characteristics, Photovoltaic effect, Photovoltaic material, Parameters of solar cells, Effects of cell temperature on cell efficiency, Types of solar cells, Solar modules and arrays, Solar cell power plant, Silicon, thin film and polymer processing, Silicon wafer based solar cells, Hybrid organic- inorganic solar cells.

UNIT – V

Solar Passive Architecture: Thermal comfort, bioclimatic classification.
Passive heating concepts: direct heat gain, indirect heat gain, isolated gain and sunspaces
Passive cooling concepts: evaporative cooling, Radiative cooling, shading - paints and cavity walls for cooling, roof radiation traps, thermal comfort.

Text Books:

1. Solar Energy-Principles of Thermal Collection and Storage, S P Sukhatme & J K Nayak, McGraw Hill Education, 3rd Edition,2009, ISBN : 9780070142961.
2. Principles of Solar Engineering, D.Yogi Goswami, Frank Krieth and Jan F. Kreider Taylor and Francis, 2nd Edition,2000, ISBN : 9781560327141.

Reference Books:

1. Solar Energy- Fundamentals, Design, Modelling and Applications, G.N.Tiwari, Narosa publishing house. 1st Edition, ISBN : 9780849324093.
2. Solar Energy and Non-conventional Energy Sources, Domkundwar, Dhanpat Rai & Co, (P) Ltd., 2nd Edition, ASIN : B0BQWR83GF

Web Links:

1. https://archive.nptel.ac.in/courses/115/103/115103123/
2. https://www.nrel.gov/research/re-solar.html

Alternative Fuels for IC Engines

Course Code: 241ME038	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the course, student will be able to:

CO1: Explain about conventional and alternative fuels for ICengines and BS emission standards.
CO2: Explain the characteristics of alcohols in SI & CI engines.
CO3: Determine properties of biodiesels and their significance in IC engines.
CO4: Illustrate the storage and safe handling techniques of Hydrogen.
CO5: Analyze the various gaseous alternative fuels for IC engine applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1			2					2
CO2	3	2	1			2	1				1
CO3	3	2	1			2	1				1
CO4	3	2	1			2	1				1
CO5	3	2	1			2	1				1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		1
CO2		1
CO3		1
CO4		1
CO5		1

UNIT – I

Introduction to Alternative Fuels:

Needs of alternative fuels - Sources of fossil fuels, Status of petroleum reserves, economics. Review of fuel properties Constituents of exhaust gas emissions- environmental and health safety, green house effect.Emission norms as per Bharat Standards up to BS – VI.

Alternative fuels: Classification, importance in solving energy crisis and environmental issues.

UNIT – II

Alcohols:

Sources of Methanol and Ethanol, methods of its production. Properties of methanol & ethanol as engine fuels. Performance of blending with gasoline. Improvement in performance and emission characteristics with respect to blending of alcohol.

UNIT – III

Biodiesels:

Feed stocks-Preparation of Biodiesel: Biodiesel production from Vegetable oils, Properties of biodiesel and their importance in the context of performance and emissions of IC Engines.

Recycled Fuels: Pyrolysis- plastic, tyre and cooking oils.

UNIT – IV

Hydrogen:

Sources and methods of Production of hydrogen. Properties, Storage and Transportation. Advantages and disadvantages use of hydrogen in SI and CI engines. Hazards and safety systems for hydrogen usage, combustion and emission from hydrogen.

UNIT – V

Biogas:

Introduction to Biogas system, Process during gas formation, Factors affecting biogas formation. Usage of Biogas in SI engine & CI engine.

LPG & CNG: Properties of LPG & CNG used as engine fuels, storage and transportation, combustion characteristics, effect on performance, emission, cost and safety.

Text Books:

1. Alternate Fuels, S. S. Thipse, Jaico Publications,1st Edition, ISBN : 9788184950786.
2. Alternative Fuels and Advanced Vehicle Technologies kavathi venkateswarlu PHI publications,2021, ISBN : 9788194685166.

Reference Books:

1. Richard L.Bechtold, Alternative Fuels Guidebook, Society of Automotive Engineers (SAE), ISBN : 9780768000528.
2. Internal Combustion Engine Fundamentals Heywood, J.B., McGraw-Hill,1st Edition, ISBN : 9781259002076.

Web Links:

1. https://archive.nptel.ac.in/courses/112/103/112103262/
2. https://archive.nptel.ac.in/courses/103/105/103105110/

Fuel Cell Technology

Course Code: 241ME039

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Apply the basic principles of fuel cell operation, including electrochemical reactions and cell thermodynamics.
- **CO2:** Analyse the fuel cell electro chemistry and membranes used for fuel cells
- **CO3:** Identify and describe the key components of a fuel cell system, such as the anode, cathode, electrolyte and bipolar plates.
- **CO4:** Apply the chemical and physical principles of fuel processing.
- **CO5:** Discuss the integration of fuel cells into various applications

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2				2					1
CO2	3	3				2					
CO3	2	2				2					
CO4	3	2				2					
CO5	3	2				2					1

Mapping of Course Outcomes with Program specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		3
CO2		3
CO3		3
CO4		3
CO5		3

Unit-I

Overview of Fuel Cells: Description of fuel cell, brief history, classification, working principle,

Fuel cell basic chemistry and thermodynamics of fuel cell and performance.

Fuel Cell Thermodynamics: Free energy change of a chemical reaction, heat of reaction, reversible and net output voltage, theoretical fuel cell efficiency, effect of pressure.

Unit-II

Fuel Cell Electrochemistry: Electrode kinetics, Butler-Volmer equation, voltage losses, cell potential-polarization curve, fuel cell efficiency.

Membranes for fuel cells: Nafion – Polymer blends and composite membranes; assessment of performance – recent developments.

Unit-III

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others, hydrogen generation and storage; limitations, recent advances.

Fuel Cell Components: Materials, properties, processes, membrane, electrodes, bipolar plates, stack design, hydrogen and oxygen supply systems, PEM fuel cell.

Unit-IV

Fuel processing: Direct and in-direct internal reforming, Production of hydrogen, Reformation of hydrocarbons by steam, CO2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs.

Unit-V

Fuel Cell Applications: Automobiles, stationary power, fuel cells and hydrogen economy, medium and high temperature fuel cells.

Text Books:

1. Fuel Cell Fundamentals, Ryan O′Hayre, Suk-Won Cha Whitney Colella, John Wiley & Sons Inc, 3rd edition, ISBN : 9781119113805.
2. Fuel cells – Principles and Applications, M. Aulice Scibioh and B. Viswanathan, CRC Press, 1st edition, ISBN : 9781420060287.

Reference Books:

1. Fuel cells for Automative Applications, RH Thing, Professional Engineering Publishing, 1st edition, ISBN : 9781860584237.
2. Fuel Cells – From Fundamentals to Applications, Srinivasan, Springer -Verlang New York Inc, ISBN : 9780387251165.

Web Links:

1. https://www.coursera.org/specializations/battery-technologies
2. https://nptel.ac.in/courses/103102015
3. https://elearn.nptel.ac.in/shop/iit-workshops/completed/battery-cell-technology-materials-and-industrial-applications/?v=c86ee0d9d7ed

Refrigeration & Air Conditioning

Course Code: 241ME040	L	T	P	C
	2	1	0	3

Course Outcomes:

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

- **CO1:** Explain the principle and applications of air refrigeration system.
- **CO2:** Describe vapour compression refrigeration system.
- **CO3:** Explain different types of vapour absorption refrigeration system.
- **CO4:** Describe air-conditioning processes using the principles of Psychrometry.
- **CO5:** Calculate loads in air-conditioning system and explain different heat pump circuits.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2				1					
CO2	3	2				1					
CO3	3	2				1					
CO4	2	3				1					
CO5	3	2				1					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		3
CO5		3

UNIT – I

Introduction to Refrigeration: Necessity, application, unit and C.O.P of refrigeration, Reversed Carnot cycle, Bell Coleman cycle with its numerical problem, Air Refrigeration System (ARS), Open & Dense air system, Refrigeration system used in air crafts and its problem. Classification of Refrigerants & its Properties, Nomenclature, Ozone layer Depletion, Global Warming.

UNIT – II

Vapour Compression Refrigeration System (VCRS): Simple Vapour Compression Refrigeration Cycle, Comparison between ARS & VCRS, Representation of cycle on T-S and P-H charts, Effect of sub cooling & super heating, Actual cycle influence of various parameters on system performance, Brief description about Actual VCRS.

UNIT – III

Vapour Absorption Refrigeration System (VARS): Working principal of VARS, Comparison between VCRS & VARS, Description & working of principle of Ammonia-Water VARS, Lithium-Bromide water VARS, Principle & operation of three Fluid Absorption System. Salient features, working principle and basic components of Steam Jet Refrigeration System, Principle & operation of thermoelectric refrigeration system - Vortex tube.

UNIT – IV

Introduction to Air Conditioning: Psychometric properties & processes, Ventilation, Infiltration, Comfort conditions, Factors Affecting Human Comfort, Factors Affecting Optimum Effective Temperature, Requirements of human comfort and concept of effective temperature, comfort chart. Air Conditioning Systems: Working principle of comfort, industrial, winter, summer, year-round, unitary and central air conditioning system.

UNIT – V

Air-conditioning load calculations: Load concepts of Room Sensible Heat Factor, Grand Sensible Heat Factor and Effective Room Sensible Heat Factor. Classification of equipment used in an air conditioning system, Humidifier, filters, grills, registers, fans, and blowers. Air Handling Units, Heat pump – heat sources, Different types of heat pump circuits.

Text Books:

1. Refrigeration and Air-conditioning, Arora C.P., Tata Mc Graw –Hill, 4th edition, 2021, ISBN : 9789390385843.
2. Refrigeration and Air Conditioning, Khurmi R. S., S Chand, Revised edition, 2019, ISBN : 9788121927819.

Reference Books:

1. Refrigeration and Air Conditioning, Manohar Prasad, New Age International, Pvt Ltd, 3rd edition 2021, ISBN-13 : 978-8122436945
2. A Course in Refrigeration and Air conditioning, S. C. Arora & S. Domkundwar, Dhanpatrai, ISBN - 9788120339156.

Web Links:

1. https://nptel.ac.in/courses/112105128.
2. https://www.udemy.com/course/water-cooler-dispenser-working-and-circuit-diagram/?couponCode=NVDPRODIN35
3. https://bharatskills.gov.in/Home/StudyMaterial?var=06nHBys5P85EmOqtjA1wsA==&Default=YES

Hydraulic Machinery & Systems

Course Code: 241ME041

L	T	P	C
3	0	0	3

Course Outcomes:

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

CO1: Determine the forces exerted by a jet of fluid on stationary and moving vanes.
CO2: Differentiate types of turbines and further analyze their working principles.
CO3: Determine the performance of hydraulic turbines.
CO4: Distinguish different types of pumps and further analyze their performance.
CO5: Explain the working principles of various hydraulic systems, hydraulic control systems.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	3									
CO2	3	2									
CO3	2	3									
CO4	2	3									1
CO5	3	2									

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		3
CO2		3
CO3		3
CO4		3
CO5		3

UNIT – I

Impact of jet and jet propulsion: Impact of jet on a stationary vertical plate, stationary inclined plate, stationary curved plate, hinged plate, moving vertical and inclined, moving curved plate, series of moving flat and curved vanes, Jet propulsion.

UNIT – II

Hydraulic Turbines: General layout of hydro power plant, heads and efficiencies of turbines, classification of turbines, Impulse turbine: Pelton turbine-components, work and efficiencies, Reaction turbine: Francis turbine-construction features, work and efficiencies, draft tube theory, Axial flow turbine – Kaplan turbine, working principles and efficiencies.

UNIT – III

Performance of turbines: Unit quantities and their significance, specific speed of turbines, performance characteristic curves-constant head, constant speed and constant efficiency curves, model testing of turbines, cavitation in turbines, selection of turbines, governing of turbines.

UNIT – IV

Pumps: Classification of pumps-positive displacement and non-positive displacement, Reciprocating Pumps: Description and working, types, work done by pumps, coefficient of

discharge, slip, negative slip, Indicator diagram, acceleration head and its effects in suction and delivery pipes, effect of friction, air vessels-description, working, functions and effect of air vessels on discharge, pressure head, work, indicator diagram, maximum speed and work saved against friction, Centrifugal Pumps: Components and working principle, priming of centrifugal pumps, work done by impeller, head, losses and efficiencies, minimum starting speed, specific speed, multistage pumps, performance of pumps-characteristic curves, NPSH, cavitation.

UNIT – V

Hydraulic systems: Hydraulic accumulator-single and differential types, hydraulic intensifier, hydraulic press, hydraulic crane, hydraulic ram, hydraulic jack, hydraulic coupling and torque converter. Hydraulic control systems: components and symbols, types of control systems-closed loop and open loop, control methods, applications of control systems in turbines and machine tools.

Text Books:

1. Hydraulics and Fluid Mechanics Including Hydraulics Machines, P. N. Modi & S. M. Seth, Standard Book House, 23rd Edition, 2022, ISBN : 9788189401269.
2. Fluid Mechanics and Hydraulic machinery, R. K. Bansal, Laxmi publications, 10th edition, 2019, ISBN : 9788131808153.

Reference Books:

1. Hydraulic machines, T. R. Banga & S. C. Sharma, Khanna publishers, 2019, ISBN : 9789387394704.
2. A Textbook of Hydraulics, Fluid Mechanics and Hydraulic Machines, R. S. Khurmi, S. Chand & Company Pvt. Ltd, 19th Edition, 2019, ISBN : 9788121901628.

Web Links:

1. https://archive.nptel.ac.in/courses/112/103/112103249/.
2. https://ocw.mit.edu/courses/2-000-how-and-why-machines-work-spring-2002/resources/lecture8_hydraulicsii/
3. https://archive.nptel.ac.in/courses/112/105/112105182/

Cryogenic Engineering

Course Code: 241ME042	L	T	P	C
	3	0	0	3

Course Outcomes: At the end of the course, student will be able to:

CO1: Explain the principles of cryogenic systems.
CO2: Demonstrate the air and helium liquefaction processes.
CO3: Explain about rectification and cryogenic storage.
CO4: Explain Cryogenic Refrigeration System.
CO5: Demonstrate vacuum technology in cryogenics.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	1									
CO2	3	2									
CO3	3	2									
CO4	3	2									
CO5	3	2									

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

UNIT – I

Introduction: Historical background, Insight on Cryogenics, Definition and Engineering applications of Cryogenics, Properties of solids for cryogenic systems, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures, Mechanical properties, Thermal properties, Electrical and Magnetic Properties, Present area involving cryogenics.

UNIT – II

Gas-Liquefaction System: Carnot liquefaction cycle, F.O.M, and Yield of liquefaction Cycles, Joule-Thomson effect, Adiabatic expansion, Simple Linde-Hampson system, Precooled Linde- Hampson system, Linde dual-pressure system, Cascade system, Claude system, Kapitza system, Collins helium liquefaction system, Ortho-Para hydrogen conversion, Critical components in liquefaction systems.

UNIT – III

Separation of cryogenic gases and cryogenic Storage system: Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method, Adsorption Systems for purification.

Cryogenic Storage and transfer Systems: Cryogenic fluid storage vessels, insulations, cryogenic transfer systems.

UNIT – IV

Cryogenic Refrigeration System: Philips refrigerator, Importance of regenerator effectiveness for Philips refrigerator, Gifford-McMohan refrigerator, J. T. Cryocoolers, Stirling Cycle Refrigerators, Pulse Tube Refrigerators, Regenerators used in Cryogenic Refrigerators, Magnetic Refrigerators.

UNIT – V

Vacuum Technology: Introduction and importance of vacuum technology in cryogenics, Flow regimes in vacuum systems, Conductance in vacuum systems, Operation of vacuum pumps, Calculation of pump-down time for a vacuum systems, Components of a vacuum systems, Mechanical vacuum pumps, Diffusion pumps, Ion pumps, Cryopumping. Vacuum gauges and valves.

Text Books:

1. Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, PHI Learning, ISBN: 9788120330573
2. Cryogenic Engineering, Thomas Flynn, CRC Press, 2nd edition, 2020, ISBN : 9780367578169.

Reference Books:

1. Cryogenic Technology and Applications, A. R. Jha, Butterworth-Heinemann, 1st edition, ISBN : 9780750678872.
2. Cryogenic Mixed Refrigerant Processes, Gadhiraju Venkatarathnam, Springer-Verlag New York Inc, 2008, ISBN : 9780387785134.
3. Cryogenic Engineering: Fifty Years of Progress, Timmerhaus et. al., Springer, 2007, ISBN : 9781493999774.

Web Links:

1. https://nptel.ac.in/courses/112101004.
2. https://www.slac.stanford.edu/econf/C0605091/present/CERN.PDF.

Energy Storage Systems

Course Code: 241ME044

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Describe the different energy storage methods
- **CO2:** Explain about mechanical energy storage system
- **CO3:** Explain about thermal energy storage methods.
- **CO4:** Explain different types of electrochemical energy storage devices.
- **CO5:** Explain the design of battery for transportation.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	1									
CO2	3	1									
CO3	3	1									
CO4	3	1									
CO5	2	3									

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5	2	-

UNIT – I

Introduction: Introduction of energy storage technology, Scope, needs and opportunities in energy storage, Electricity storage services and benefits, Methods and tools for valuation of storage, Maturity of different energy storage systems and cost effects, Energy storage in the power and transportation sectors, Current electric vehicle market, Importance of energy storage systems in electric vehicles, Future prospect of storage, global energy and the required CO_2 reduction.

UNIT – II

Mechanical Energy Storage Systems

Flywheel energy storage (FES), Pumped hydropower storage (PHS), Compressed-air energy storage (CAES). Comparison and application state-of-arts including principle, function and deployments, Technical characteristics - in terms of power rating, discharge time, storage duration, energy efficiency, energy density, cycle life and life time, capital cost.

UNIT – III

Thermal energy storage (TES) methods:

Sensible TES: Working principle and classification, Properties of solid sensible storage materials, short-term/long-term storage, cool/low/medium/high-temperature storage, Sensible thermal storage technologies - storage methods in space-heating system, solar-

cooling system, solar power plant with sensible TES, Passive and active systems, Importance of thermal stratification, Strategies to enhance the thermal stratification.
Latent TES: Cold TES, Seasonal TES, Selection of phase change materials (PCM), PCMs classifications, Specific PCM applications, Mechanisms to improve PCM applications, Nanoparticle-encapsulated PCMs, Cascades of PCM systems. Design and operation of TES - Performance characteristics, testing, safety, standards and system sizing.

UNIT – IV
Electrochemical energy storage
Battery: Working principle, Types, Flow battery, Battery aging, Battery-based hybrid storage system, Fuel cell: operational principle, types, hybrid fuel cell-battery systems.
Supercapacitors: Working principle, types, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors, Comparison and application state-of-arts including principle, function and deployments, Technical characteristics of various electrochemical energy storage systems, Concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems

UNIT – V
Battery Design for Transportation
Mechanical design and packaging of battery packs for electric vehicles, Advanced battery-assisted quick charger for electric vehicles, Charging optimization methods for lithium-ion batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of charge and state of health estimation over the battery lifespan, Recycling of batteries from electric vehicles.

Text Books:
1. Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), Frank S. Barnes, Jonah G. Levine, CRC press, 1st Edition, ISBN-13, 978-1138071964.
2. Energy storage: A new approach, Ralph Zito, Wiley, 2nd Edition, 2019, ISBN-13: 9781119083597.

Reference Books:
1. Thermal Energy Storage Using Phase Change Material, Fleischer Amy S, Springer International Publishing AG,ISBN: 9783319209210.
2. Lithium-Ion Battery Design for Transportation, Alvaro Masias, Springer, 2018.

Web Links:
1. https://archive.nptel.ac.in/courses/113/105/113105102/.
2. https://nptel.ac.in/courses/112107283.
3. https://ocw.mit.edu/courses/10-626-electrochemical-energy-systems-spring-2014/resources/mi1.0_626s14_s11lec03/

Gas Dynamics & Jet Propulsion

Course Code: 241ME045	L	T	P	C
	2	1	0	3

Course Outcomes:

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

- **CO1:** Explain the principles of isentropic flow through variable ducts
- **CO2:** Explain the principles of Rayleigh flow and fanno flow in constant area ducts
- **CO3:** Explain the fundamental principles and governing equation of normal and oblique shock waves
- **CO4:** Analyse the performance of various type of jet propulsion
- **CO5:** Explain the working principle of rocket engine and performance

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									
CO2	3	2									
CO3	3	2									
CO4	3	1				2					
CO5	3	1				2					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		3
CO2		3
CO3		3
CO4		3
CO5		3

UNIT – I

Introduction:

Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility – Isentropic flow through variable ducts – Nozzle and Diffusers, Differences between Incompressible and Compressible flows.

UNIT – II

Flow through Ducts:

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) –variation of flow properties

UNIT – III

Normal and Oblique Shock Wave:

Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl – Meyer relations – Applications.

UNIT – IV

Jet Propulsion:

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines.

UNIT – V

Rocket Science:

Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights

Text Books:

1. Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion,S M Yahya New Age International Private Limited, 7th Edition, 2023, ISBN : 9789395161718.
2. Modern Compressible flow, Anderson, J.D, Third Edition, McGraw Hill, 3rd edition, ISBN : 9780072424430.

Reference Books:

1. Fundamentals of Gas Dynamics, Robert D. Zucker, Oscar Biblarz,. John Wiley & Sons Inc, 3rd Edition , 2019, ISBN : 9781119481706.
2. Fundamentals of Compressible Fluid Dynamics, Balachandran, P.,Prentice-Hall of India, ISBN : 9788120328570.

Web Links:

1. https://archive.nptel.ac.in/courses/101/108/101108086/
2. https://nptel.ac.in/courses/webcourses
3. https://www.classcentral.com/course/swayam-fundamentals-of-gas-dynamics-5293

Computational Fluid Dynamics

Course Code: 241ME046	L	T	P	C
	2	1	0	3

Course Outcomes: At the end of the course, student will be able to:

CO1: Explain the concepts of PDEs, their application to CFD problems and fundamentals of discretization.
CO2: Solve the problems related to energy equation.
CO3: Explain the concept of Finite Difference Method
CO4: Solve the problem related to Finite Different Method.
CO5: Explain and solve the problems using Finite Volume Method.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	2								
CO2	2	2	2								
CO3	2	2	3								
CO4	2	2	3								
CO5	2	2	3								

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1		2
CO2		2
CO3		2
CO4		2
CO5		2

UNIT – I

Introduction to CFD: Role of CFD and its applications, future of CFD. Introduction to heat transfer, Compressible flows, Incompressible flows.

Governing equations (GE's) of Fluid dynamics: Modelling of flow, control volume concept, Continuity equation, momentum equation, energy equation and its conservation form.

UNIT - II:

The energy equation: Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions.

Mathematical behaviour of partial differential equations: Classification of quasi-linear partial differential equations, General behaviour of Hyperbolic, Parabolic and Elliptic equations.

UNIT – III

Finite Difference Method

Basic aspects of Discretization Finite Difference, formulae for first order and second order terms, Solution of physical problems with Elliptic, type of Governing Equations for different boundary conditions Numerical treatment of 1D and 2D problems in heat conduction.

UNIT – IV

Application of Finite Difference Method

Solution of physical problems with parabolic type of Governing Equations, Initial Condition, Explicit, implicit and semi-implicit methods, Types of errors, Solution of simple physical problems in 1D and 2D.

UNIT – V

Finite Volume Method

Diffusion Problems, 1D steady state diffusion, 2D steady state diffusion, Convection-Diffusion Problems, 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness.

Text Books:

1. Introduction to Computational Fluid Dynamics, an: The Finite Volume Method, H. Versteeg, W. Malalasekera, Pearson Education Limited, 2nd Edition, ISBN : 9780131274983.
2. Introduction to Computational Fluid Dynamics Development, Application and Analysis, Atul Sharma, Wiley Publication, 1st edition, ISBN : 9781119002994.

Reference Books:

1. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, McGraw-Hill Publication, 2017, ISBN : 9781138564695.
2. Computational Fluid Dynamics, John D. Anderson, McGraw-Hill Book Company, 2017, ISBN : 9781259025969.

Web Links:

1. https://nptel.ac.in/courses/112105045
2. https://archive.nptel.ac.in/courses/112/105/112105254/

Minor Stream: Automotive Engineering

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME047	Automotive Electrical & Electronics	FC	2			2	50	50	100	BEEE
241ME048	Automotive Maintenance	IC	2		1	3	50	50	100	AE
241EE054	Hybrid & Electric Vehicles	IC	3			3	50	50	100	BEEE
241ME049	Electronic Engine Management System	IC	3			3	50	50	100	HEV
241ME050	Automotive Certification & Homologation	IC	3			3	50	50	100	AE
241ME051	Vehicle Infotronics	IC	3			3	50	50	100	AEE
241ME052	Automotive Aerodynamics	AC	3			3	50	50	100	FMHM, AE
241ME053	Automotive Noise Vibration & Harshness	AC	3			3	50	50	100	DOM
241ME054	Vehicle Stability & Control	AC	3			3	50	50	100	AE
241ME055	Special Purpose Vehicles	AC	3			3	50	50	100	AE
241ME056	Automotive & Pedestrian Safety	AC	3			3	50	50	100	AE
	Total		**31**		**1**	**32**				

Automotive Electrical & Electronics

Course Code: 241ME047	L	T	P	C
	2	0	0	2

Course Outcomes:

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

- **CO1:** Explain the Construction and working of different Batteries and Automotive Electrical accessories
- **CO2:** Explain about the Starting system
- **CO3:** Describe about the Charging system
- **CO4:** Explain about the fundamentals of Automotive Electronics
- **CO5:** Describe about the Sensors & Actuators

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	1	2			1	1				1
CO2	2	1									1
CO3	2	1									1
CO4	3	1									1
CO5	2	1									1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Batteries and Accessories:

Principle and Construction of Lead Acid Battery, Characteristics of battery, rating capacity and Efficiency of Batteries, Maintenance and Charging.

Lighting System: Insulated and Earth Return System, Details of Head Light and Side Light, LED Lighting System, Head Light Dazzling and Preventive Methods – Horn, Wiper System and Trafficator.

UNIT – II

Starting System

Behavior of Starter during Starting, Series Motor and its Characteristics, Principle and Construction of Starter Motor, Working of Different Starter Drive Units, Care and Maintenances of Starter Motor, Starter Switches.

UNIT – III

Charging System

Generation of Direct Current, Shunt Generator Characteristics, Armature Reaction, Third Brush Regulation, Cutout. Voltage and Current Regulators, Compensated Voltage Regulator, Alternators Principle and Constructional Aspects and Bridge Rectifiers, New Developments.

UNIT – IV

Fundamentals of Automotive Electronics

Current Trends in Automotive Electronic Engine Management System, Electro Magnetic Interference Suppression, Electromagnetic Compatibility, Electronic Dashboard Instruments, Onboard Diagnostic System, Security and Warning System.

UNIT – V

Sensors & Actuators:

Types of Sensors: Sensor for Speed, Throttle Position, Exhaust Oxygen Level, knock, Manifold Pressure, Crankshaft Position, Coolant Temperature, Exhaust Temperature, Impact sensor, Air Mass Flow for Engine Micromechanical yaw-rate sensors, Accelerator-pedal sensors, Position sensors for transmission control Steering-angle sensors, Axle sensors, Application. Solenoids, Stepper Motors, Relay.

Text Books:

1. Automotive Electrical Equipment, Young A.P. & Griffiths.L, ELBS & NewPress, ISBN-10. 0592006352
2. Understanding Automotive Electronics, William B.Riddens, Butter worth Heinemann Woburn, 5th edition,ISBN-13**. 978-0750670081**

Reference Books:

1. Modern Electrical Equipment of Automobiles, Judge A.W , Chapman & Hall, London, 1st edition, 2012, ISBN: 9789401168830.
2. Automotive Electrical Equipment, Kohli .P.L, Tata McGraw-Hill Co., Ltd., New Delhi, 1st edition, 2017, ISBN 9780074602164 :.

Web Links:

1. https://www.udemy.com/course/basics-of-automotive-electronics/?couponCode=LEADERSALE24A
2. https://www.rv-skills.com/electric-vehicle-embedded-systems-courses-jobs.php

Automotive Maintenance

Course Code: 241ME048

L	T	P	C
2	0	1	3

Course Outcomes:

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

- **CO1:** Explain the procedure involved in Inspection Schedule And Maintenance of Records
- **CO2:** Plan the Engine manintenance activities
- **CO3:** Plan the Chassis manintenance activities
- **CO4:** Plan the Electrical system manintenance activities
- **CO5:** Plan the Electronic system manintenance activities

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1			1			1	2			1
CO2	1			1			1	2			1
CO3	1			1			1	2			1
CO4	1			1			1	2			1
CO5	1			1			1	2			1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Inspection Schedule and Maintenance of Records

Need for maintenance, types of maintenance: preventive and breakdown maintenance, requirements of maintenance, preparation of check lists. Inspection schedule, maintenance of records, log sheets and other forms, safety precautions in maintenance: general safety, tool safety.

Practice:

1. Demonstration of Standard Preventive Maintenance Sheet
2. Demonstration of Inspection sheet of a typical Automotive vehicle at Service centre

UNIT – II

Engine Maintenance

Tools used for engine disassembly, dismantling of engine components: cylinder head, valve train, cylinder block, connecting rod, piston and crankshaft assembly; cleaning and inspection of engine components, reconditioning of components, servicing and maintenance of fuel system, engine tune-up, cooling system: water pump, radiator, thermostat. Lubrication system maintenance, anticorrosion and anti-freeze additives

Practice:

1. Dismantling and assembling of typical automotive engine
2. Servicing & maintenance of MPFI of SI engine and Fuel Injection system (Fuel Injection pump and Injector) of a CI engine.

UNIT – III

Chassis Maintenance

Servicing and maintenance of clutch, gear box, universal joints, propeller shaft, differential system. Service and maintenance of brake – disc and drum brakes, steering wheel and suspension systems, wheel alignment, and vehicle body maintenance.

Practice:

1. Servicing & maintenance of Drivetrain components (any two)
2. Demonstration and practice of Wheel alignment for a typical automotive vehicle
3. Demonstration and practice of Wheel Balancer

UNIT – IV

Electrical System Maintenance

Servicing and maintenance of battery, starter motor, alternator and generator, ignition system lighting system, electric horn, and wiper motor.

Practice:

1. Servicing & maintenance of Electric motors used in Automotive vehicle (any two)
2. Servicing & maintenance of Electric equipment of a typical Automotive vehicle (any two)

UNIT – V

Electronic System Maintenance

On Board Diagnostics of different types and procedures adopted in testing the vehicles. Fault diagnostics of different sensors and actuators, Maintenace of ECU and its possible errors and its detection with possible preventive and breakdown maintenance. Maintenance of Dashboard instruments.

Practice:

1. Demonstration of testing of Engine functioning using Onboard Diagnostics
2. Servicing & maintenance of dashboard electronics (any two)

Text Books:

1. An Introductory Guide to Motor Vehicle Maintenance: Light Vehicles, Knott and Phil Knott, EMS publishing, 2010, ISBN : 9781903348246.

2. Vehicle Maintenance and Garage Practice, Jigar A Doshi, PHI Pub, 1st edition, ISBN-13: 978-8120349827.

Reference Books:

1. An Introduction to Modern Vehicle Design, JullianHappian-Smith, SAE, 2001, ISBN :9780750650441.

2. Automotive service: Inspection, maintenance and repair, Tim Giles, 3rd edition, ISBN: 9781418037581.

Web Links:

1. https://www.udemy.com/course/automotive-ownership maintenance/?couponCode=LEADERSALE24A

2. https://www.classcentral.com/course/udemy-automotive-101-46082

Hybrid & Electric Vehicles

Course Code: 241EE054

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Describe the History of Hybrid Electric vehicles
- **CO2:** Classify the various electric drivetrain topologies
- **CO3:** Articulate the Energy Storage Requirements in Hybrid and Electric Vehicles
- **CO4:** Illustrate the Charging Infrastructure
- **CO5:** Evaluate Energy Management Strategies used in hybrid and electric vehicle

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1		1			1					1
CO2	1	1	1		1	1					1
CO3	3	2	3	2	2	2					1
CO4	2	1	2	1	1	2					1
CO5:	3	3	3	3	3	2					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies-Challenges and Key Technologies of EVs – Challenges for EV Industry in India

UNIT – II

Electric Drive-trains:

Basic concept of electric traction - introduction to various electric drivetrain topologies - Power flow control in electric drive-train topologies - fuel efficiency analysis-various hybrid drive-train topologies.

Electric Propulsion unit:

Introduction to electric components used in hybrid andelectric vehicles, configuration and control of DC Motor drives, configuration andcontrol of Induction Motor drives, configuration and control of permanent magnetmotor drives, configuration and control of switch reluctance motor drives, drive system efficiency.

UNIT – III

Energy Storage:

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles -Battery based - Fuel Cell based - Super Capacitor based - Flywheel based its analysis

UNIT – IV

Sizing the drive system:

Matching the electric machine and the internal combustion engine (ICE), Sizing thepropulsion motor, sizing the power electronics, selecting the energy storage technology,Communications,supporting subsystems.

UNIT – V

Energy Management Strategies

Introduction to Energy Management Strategies used in hybrid and electric vehicle, Classification of different Energy Management strategies - Comparison of different Energy Management Strategies - Implementation issues of energy strategies - Effect of charging infrastructure on grid protection and control - Role of advanced metering infrastructure (AMI)/Smart Meters in EV Management.

Text Books:

1. Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley-Blackwell (ISBN: 9781119942733).
2. Energy Management Strategies for Electric & Plug-in Hybrid Electric Vehicles, Sheldon S. Williamson, Springer (ISBN: 9781493955237).

Reference Books:

1. Electric Vehicle Battery Systems, Sandeep Dhameja, Elsevier (ISBN: 9780750699167).
2. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press (ISBN: 9781138072855).
3. Hybrid electric Vehicles Principles & applications with practical perspectives, Chris Mi,M. Abul Masrur, D. Wenzhong Gao, A Dearborn, John Wiley & Sons Ltd (ISBN: 9781118970560).

Web Links:

1. https://nptel.ac.in/courses/108102121
2. https://nptel.ac.in/courses/108103009
3. https://www.nrel.gov/research/transportation-hybrid-electric.html

Electronic Engine Management System

Course Code: 241ME049

L	T	P	C
3	0	0	3

Course Outcomes:

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

CO1: Make use of different Sensors and Actuators for Computerized Electronic Fuel Injection
CO2: Analyse the Speed Density/Mass Air Flow Fuel Management Strategies
CO3: Analyse the Engine Diagnostic Procedures
CO4: Analyse the SI Engine Management system
CO5: Analyse the CI Engine Management system

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	2		1	1	1				1
CO2	3	3	3		1	1	1				1
CO3	3	3	3		1	1	1				1
CO4	3	3	3		1	1	1				1
CO5	3	3	3		1	1	1				1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PO	PSO1	PSO2
CO1	2	3
CO2	1	3
CO3	1	3
CO4	1	3
CO5	1	3

UNIT – I

Computerized Electronic Fuel Injection

Engine Input Sensors Coolant & Intake Temperature, Crankshaft Position, Camshaft Position, Manifold Absolute Pressure, Throttle Position, Oxygen, Air/Fuel Ratio, Knock Speed & Distance, Battery & Switches Output Devices -Relays, Injector Sequencing & Management, Ignition Operation, Idle Air Control, EGR, EVAP, Waste gate Solenoids, Torque Converter & Speed Control, Malfunction Indicator Light

UNIT – II

Speed Density/Mass Air Flow Fuel Management Strategies

Key ON Mode, Crank Mode, Open & Closed Loop, Wide-Open Throttle, Adaptive Memory Cells, Cruise & Deceleration, Wide-Open Throttle, Key OFF Mode Fuel Injection Systems -Electronic Fuel Systems, Computer Self-Diagnostic Circuits, Electronic Throttle Actuator Control Systems, Fuel Control, Fuel Supply System Control, Injection System Inspection and Maintenance.

UNIT – III

Engine Diagnostic Procedures

On Board Diagnostics, Monitored & Non Monitored Circuits, Diagnostic Trouble Codes, engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cut off. future automotive electronic systems, Electronic dash board instruments – Onboard diagnosis system.

UNIT – IV

SI Engine Management System

Feedback throttle body injection, multi-point fuel injection and direct injection systems, Layout and working of SI engine management systems Group and sequential injection techniques. Advantages of electronic ignition systems. Contactless electronic ignition system, Electronic spark timing control. Three-way catalytic converter, conversion efficiency versus lambda.

UNIT – V

CI Engine Management System

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.

Text Books:

1. Diesel Engine Management, Robert Bosch, SAE Publications, 3rd Edition, ISBN : 9780470026892.
2. Gasoline Engine Management, Bosch, SAE Publications, 2nd Edition, ISBN : 9781860584343.

Reference Books:

1. Automotive Fuel and Emissions Control Systems Upper Saddle River Halderman, J. & Linder, JNJ, Pearson Education, 3rd Edition, ISBN : 9780132542920.
2. Diagnosis & Troubleshooting of Automotive Electrical, Electronic, &Computer Systems, Halderman, J. DUpper Saddle River, NJ: Pearson Education, 6th Edition, ISBN 9780132551557 : .
3. Automotive Computers & Digital Instrumentation, Robert N. Brandy, Prentice Hall, ISBN : 9780137443277.

Web Links:

1. https://www.autotrainingcentre.com/automotive-online-training/engine-management-simulation/
2. https://www.delphiautoparts.com/en-gb/workshop-solutions/delphi-academy/training-academy-courses/vehicle-electronics-engine-management

Automotive Certification & Homologation

Course Code: 241ME050

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Classify the vehicle and identify the regulations governing for each vehicle type
- **CO2:** Analyse the Vehicle Performance Testing
- **CO3:** Analyse the Road and Track Testing
- **CO4:** Analyse the different Active and Passive Safety Testing
- **CO5:** Analyse the different Automotive Components testing

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	3	3	1		1					1
CO2	3	3	3	3		3					1
CO3	3	3	3	3		3					1
CO4	3	3	3	3		3					1
CO5	3	3	3	3		3					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Introduction

Specification & Classification of Vehicles, Regulations overview(ECE, FMVSS, AIS, CMVR, ADR), Type approval and Conformity of Production, Engine and Vehicle specifications, Two Wheeler certification.

UNIT – II

Vehicle Performance Testing

Methods for evaluating vehicle performance- energy consumption (well to wheel) in conventional automobiles, performance, emission and fuel economy, Operation at full load and part load conditions, effect of vehicle condition, tyre and road condition and traffic condition and driving habits on fuel economy, Gradeability test, Turning circle diameter test, Steering Impact test, Steering effort test.

UNIT – III

Road and Track Testing:

Initial inspection, PDI, engine running in and durability, intensive driving, maximum speed and acceleration, brake testing on the road, hill climbing, handling and ride characteristics, safety, mechanism of corrosion, three chamber corrosion testing, wind tunnel testing, road testing, test tracks, coast down test, Portable exhaust measurement system.

UNIT – IV

Active and Passive Safety Testing

Wheel rim testing for cornering and radial fatigue, Fire resistance test, bumper test, crash test, side impact test, rollover test, safety belt test, Airbag test, Safety belt anchorages, Seat anchorages & head restraints, Occupant protection Impact test, Side door intrusion test.

UNIT – V

Components Testing

Size and Ply rating of tyres, Safety Glasses, Wind screen wiping system, Hydraulic brake hose, Hydraulic brake fluid, Rear view mirror specification (Exterior), Rear view mirror specification (Interior), Wheel rims, Wheel nut, Wheel discs & hub caps, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints, door locks & door retention. Overview and study of testing standards like; AIS testing standards, Euro Standards, SAE standards. ISO26262 standards for functional safety of electrical and/or electronic systems in automobiles.

Note: Compulsory visit of either ARAI/CIRT/iCAT/IDIADA testing agencies to the students

Text Books:

1. Vehicle Accident Analysis and Reconstruction Methods, Raymond M. Brach and R. Matthew Brach, SAE International, 3rd edition, 2022, ISBN : 9781468604191.
2. Automotive Industry Standards, AIS.

Reference Books:

1. Automotive Safety Handbook, Ulrich Seiffert and Lothar Wech, SAE International, 2nd edition, ISBN : 9780768017984.
2. ISO Standards, ICS: 43.020, 43.040, 43.100

Web Links:

1. https://www.araiindia.com/services/certification-and-standardisation/automotive-certification-%7C-automotive-homologation-%7C-arai
2. https://www.ul.com/services/automotive-homologation-training

Vehicle Infotronics

Course Code: 241ME051	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the holistic view of Vehicle Infotronics
- **CO2:** Identify the different Electronics systems of a typical Automobile
- **CO3:** Explain about the Telematics
- **CO4:** Analyze the different Intelligent vehicle control systems
- **CO5:** Explain about the Adaptive Control system of a vehicle

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	2	1		1						1
CO2	1	2	2		1						1
CO3	3	2	2		2						1
CO4	3	2	3		3						1
CO5	3	2	3		3						1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Overview of Infotronics

Concept of Infotronics, Web-enabled Vs Web Based systems, Applications of Infotronics, Vehicle buses and protocols – LIN, CAN, MOST & Flexray, AUTO SAR

UNIT – II

Electronic based Systems in vehicle

Smart control of Vehicle[ESP] dynamics, drive Electronic Throttle control by wire, active suspensions/mounting system, Automated Guided Vehicles(AGV), Multi-disciplinary optimization in Vehicles (MDO) and advanced propulsion systems(APS), Radio Communication Technologies For Vehicle Information Systems, IEEE 802.11 and DSRC.

UNIT – III

Telematics

Global positioning systems, geographical information systems, navigation systems, automotive vision system, road recognition, driver assistance systems.

UNIT – IV

Intelligent vehicle Control

Active and Semi active suspensions/Mounts for NVH, Optimization and stability of Hydraulic Engine mounts and Bushing in Vehicle, Rollover control and Active stability

control, combined control of ride comfort in passenger cars, Active Roll over control in hydraulically actuated articulated vehicles, intelligent drive by wire vehicles, Design and realization of steer and brake by wire.

UNIT – V

Adaptive Control System

Conventional control schemes, system model for adaptive control, Design of self-tuning controllers, ACC overview, system based on ACC, Stop and Go, Anti- collision system, Impact of ACC on traffic and drivers, Adaptive noise control, automatic and adaptive control of highway traffic and moving vehicles. Power steering and power window: Requirements, Introduction, characteristics.

Text Books:

1. Intelligent Vehicle Technology, L Vlacic, M PARENT, F HARA, Butterworth-Heinemann publication, ISBN : 9780750650939.
2. Navigation and Intelligent transportation systems, Ronald K. Jurgen, SAE, ISBN 9780768002645 : .

Reference Books:

1. Robert Bosch, Automotive Hand Book, SAE, 11th edition, 2022, ISBN: 9781119911906.
2. Understanding Automotive Electronics, Willam B. Ribbens, SAE, 8th edition, , ISBN : 9780128104347.

Web Links:

1. https://www.udemy.com/course/automotive-communication-busses-can-lin-and-flexray/?couponCode=LEADERSALE24A
2. https://academy.nit-institute.com/course/vehicle-networks-and-infrastructure/

Automotive Aerodynamics

Course Code: 241ME052

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the importance of Automotive Aerodynamics on vehicle Performance
- **CO2:** Analyze the Aerodynamic forces on Passenger Vehicles
- **CO3:** Analyze the Aerodynamic forces on high performance Vehicles
- **CO4:** Analyze the Aerodynamic forces on Commercial Vehicles
- **CO5:** Examine the Automotive vehicle with respect to Stability, Saftey and Comfort

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3	3	3		1					1
CO2	3	3	3	3		1					1
CO3	3	3	3	3		1					1
CO4	3	3	3	3		1					1
CO5	3	3	3	3		1					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	3
CO2	3	3
CO3	3	3
CO4	3	3
CO5	3	3

UNIT – I

Fundamentals of Aerodynamics

Scope – Development trends – Flow phenomena related to vehicles – External and Internal flow problems – body shapes, Performance of cars and light vans – Resistance to vehicle motion – Drag – Types of Aerodynamic forces — Aerodynamic development of cars – Optimization of car bodies for low drag

UNIT – II

Aerodynamic Drag of Passenger Vehicles

Passenger car as a bluff body, Flow field around passenger car, Analysis of Aerodynamic Drag on Fore body, Wind Shield A-Pillar, roof, vehicle rear end, side of the vehicle, underside, wheels and wheel wells, rear spoiler, attachments, and Trailer & Luggage racks

UNIT – III

Aerodynamic forces on high performance vehicles

Introduction, influence of aerodyamic forces on high performance vehilces handling driving, Yawed airflow, draughting, low drag alternative designs, sonic speed vehicles, Trends in future high -performance vehicle development.

UNIT – IV

Aerodynamic forces on Commercial vehicles

Tractive resistance & fuel consumption, Aerodynamic drag coefficients of different commercial vehicles, Drag as a function of yaw angle, wind influence, cab shape, drag reducing devices for trucks, Future trends in tractor trailer designs.

UNIT – V

Stability, Safety and Comfort

The origin of forces and moments – effects – vehicle dynamics under side wind – Force and Moment coefficients – Safety limit – dirt accumulation on vehicle – wind noise – Air flow around individual components – High performance vehicles – Very long drag cars – Design alternatives – High efficiency radiator arrangement.

Text Books:

1. Theory and Applications of Aerodynamics for Ground Vehicles, Yomi Obidi, SAE Publications, 2014, ISBN : 9780768021110.
2. Aerodynamics of Road Vehicles, W.H. Hucho, SAE Publications, 4th edition, ISBN : 9780768000290.

Reference Books:

1. The Aerodynamics of Heavy Vehicles, R.McCallen, Browand, Ross, Springer, ISBN : 9783642535864.
2. Flow Visualization: Techniques and Examples, Smits, Lim, Imperial College, 2nd Edition, ISBN : 9781848167919.

Web Links:

1. https://www.edx.org/learn/engineering/massachusetts-institute-of-technology-introduction-to-aerodynamics
2. https://onlinecourses.nptel.ac.in/noc22_ae09/preview

Automotive Noise Vibration & Harshness

Course Code: 241ME053	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the Fundamentals of Acoustics and Noise, Vibration
- **CO2:** Analyse the Effects of Noise, Blast, Vibration, and Shock
- **CO3:** Identify sources of noise and vibration in automotive applications
- **CO4:** Identify the Vehicle Interior Noise and Vibration Sources and Control
- **CO5:** Explain the Noise And Vibration Transducers, Signal Processing, And Measuring Techniques

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3		3	3						1
CO2	3	3		3	3						1
CO3	3	3		3	3						1
CO4	3	3		3	3						1
CO5	3	3		3	3						1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Fundamentals of Acoustics and Noise, Vibration

Theory of Sound—Predictions and Measurement, Sound Sources, Sound Propagation in the Atmosphere, Sound Radiation from Structures and their Response to Sound, General Introduction to Vibration, Vibration of Simple Discrete and Continuous Systems, Random Vibration, Response of Systems to Shock, Passive Damping

UNIT – II

Effects of Noise, Blast, Vibration, and Shock

General Introduction to Noise and Vibration Effects on People and Hearing Conservation, Noise-Induced Annoyance, Effects of Infrasound, Low-Frequency Noise, and Ultrasound on People, Auditory Hazards of Impulse and Impact Noise, Effects of Intense Noise on People and Hearing Loss, Effects of Vibration on People, Effects of Mechanical Shock on People, Rating Measures, Descriptors, Criteria, and Procedures for Determining Human Response to Noise.

UNIT – III

Vehicle Noise and Vibration—Sources, Prediction, and Control

Introduction to Vehicle Noise and Vibration Sources, Internal Combustion Engine Noise Prediction and Control—Diesel, Exhaust and Intake Noise and Acoustical Design of Mufflers, Tire/Road Noise—Generation, Measurement, and Abatement, Aerodynamic Sound Sources in Vehicles—Prediction and Control, Transmission and Gearbox Noise and Vibration Prediction and Control, Brake Noise Prediction and Control.

UNIT – IV

Vehicle Interior Noise, Vibration Prediction Control

Introduction to Vehicle Interior Noise and Vibration Sources, Automobile, Bus, and Truck and Off-Road Vehicle.

UNIT – V

Noise and Vibration Transducers, Signal Processing, and Measuring Techniques

Introduction to Noise and Vibration Transducers, Measuring Equipment, Measurements, Signal Acquisition, and Processing, Acoustical Transducer Principles and Types of Microphones, Vibration Transducer Principles and Types of Vibration Transducers, Sound Level Meters, Noise Dosimeters, Analyzers and Signal Generators, System for Data Acquisition, Noise and Vibration Measurements and Data Analysis.

Text Books:

1. Vibration Monitoring, Testing, and Instrumentation, Clarence W. de Silva , CRC Press, 1st edition, ISBN9781420053197 : .
2. Engineering Noise Control: Theory and Practice, David A.Bies and Colin H.Hansen, Spon Press, London, 4th edition, ISBN : 9780415487078.

Reference Books:

1. Shock and Vibration Handbook, Allan G. Piersol,Thomas L. Paez Harris, McGraw-Hill, New Delhi, 6th edition, ISBN : 9780071508193.
2. Understanding Active Noise Cancellation, Colin H Hansen, Spon Press, London, 1st edition, ISBN : 9780415231916.
3. Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles, Matthew Harrison, Elsevier Butterworth-Heinemann, Burlington, ISBN : 9780750661294.

Web Links:

1. https://www.ansys.com/en-in/blog/what-is-automotive-nvh#:~:text=What%20is%20NVH%3F,is%20coming%20from%20and%20why.
2. https://www.sciencedirect.com/topics/engineering/noise-vibration-and-harshness

Vehicle Stability & Control

Course Code: 241ME054

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Develop the Mathematical Model for a given Automotive system or Sub- system
- **CO2:** Analyze the Static and Dynamic Loads of a given Vehicle
- **CO3:** Analyze the Vehicle stability for various types of Loads
- **CO4:** Analyze the Road Exciatons of the given Vehicle
- **CO5:** Analyze the Steady state cornering for the stability of the vehicle

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3	3	3		2					1
CO2	3	3	3	3		2					1
CO3	3	3	3	3		2					1
CO4	3	3	3	3		2					1
CO5	3	3	3	3		2					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Introduction:

Hypothetical vehicle control loop, Fundamental Approach, Vehicle coordinates, motion variables. Forces – Dynamic axle loads, Static loads on level ground, hitch forces and Mathematical modeling of Automotive vehicles and their sub systems.

UNIT – II

Acceleration & Braking Performance:

Power limited acceleration, Fundamental Expressions, Constant retardation, Wind Resistance, Power, Braking forces, Brakes: disc and drum, front, rear and four wheel braking, Road friction rolling resistance.

UNIT – III

Stability of Vehicle:

Aerodynamic, Mechanics of pressure distribution – Aerodynamic forces: lift & drag, Spoilers, Lift force, side force and roll, pitch and yaw moments, Crosswind sensitivity. Rolling Resistance, Factors affecting pressure, velocity, slip, temperature– Total road loads – Fuel Economy Effects.

UNIT – IV

Ride Excitation sources:

Road roughness, wheel assembly, driveline excitation, engine transmission. Vehicle response properties: Suspension isolation, suspension stiffness & damping Wheel Hop Resonance. Road-tyre friction – dynamic response of tires – Rigid body bounce, pitch motion. Perception of ride and other vibration forms.

UNIT – V

Steady – State Cornering:

Introduction, Low and high speed turning –Tire cornering forces, governing expressions, understeer, over steer and neutral conditions. Characteristic speed, critical speed, yaw velocity gain, sideslip angle, static margin. Suspension effects on cornering: roll moment distribution – effect of tractive forces on cornering.

Text Books:

1. Fundamentals of Vehicle dynamics, Thomas Gillespie, Society of Automotive engineers Inc, ISBN : 9781560911999.
2. Theory of Ground Vehicles, Wong H, McGraw Hill, 2nd edition, ISBN : 9780471524960.

Reference Books:

1. Tire and Vehicle Dynamics, Hans B Pacejka, Elsevier Ltd, 3rd Edition, ISBN : 9780080970165.
2. Vehicle Dynamics, Amitosh D, Galgotia Book Ltd, 2011, ISBN : 9788175156357.

Web Links:

1. https://nptel.ac.in/courses/107106080
2. https://www.sae.org/learn/content/99020/

Special Purpose Vehicles

Course Code: 241ME055

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Classify the different Earth Moving Equipment
- **CO2:** Articulate the different Constructional Equipment
- **CO3:** Classify the different Farm Equipment
- **CO4:** Classify the different Industrial Vehicles
- **CO5:** Distinguish the different Military and Combat Vehicles

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1	1			1	3					1
CO2	2	1			1	3					1
CO3	2	1			1	3					1
CO4	2	1			1	3					1
CO5	2	1			1	3					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Earth Moving Equipment

Construction layout, capacity and applications of dumpers, articulated haulers, front-end loaders, backhoe loaders, bulldozers, scrappers, motor graders, skid steer loaders, excavator, hydraulic shovels, bucket conveyors, surface miners – high wall Miners. Selection criteria of prime mover for dumpers.

UNIT – II

Constructional Equipment

Construction layout, capacity and applications of cranes – types , Articulated Trucks ,concrete ready mixer, trenchers, Scrapers, Asphalt Pavers , road recliners, Compactors – types , draglines, drillers, borewell machine.

UNIT – III

Farm Equipment

Classification of tractors – Main components of tractor. Working attachment of tractors – Auxiliary equipment - Top lifting harvesters. General description, working, specification and functions paddy harvesting machines, Sugarcane harvesting, feller bunchers, forest machines.

UNIT – IV

Industrial Vehicles

Constructional features, capacity and working of fork lifts, Utility vehicles, towing vehicles, man-lift chassis, scissor lift trucks, material handlers, Street sweepers.

UNIT – V

Military And Combat Vehicles

Special features and constructional details of Main Battle tank, gun carriers, transport vehicles, Armoured vehicle-launched bridge, amphibious bridging vehicle, communication vehicles.

Text Books:

1. Road making Machinery, Abrosimov. K. Bran berg.A. and Katayer.K, MIR Publishers, Moscow, ISBN 9780750665940
2. Tractor and Automobiles, Rodichev and G.Rodicheva, MIR Publishers, ISBN : 9785030008554.

Reference Books:

1. Theory of Ground vehicles, Wong.J.T, John Wiley & Sons, New York, 4th edition, 2008, ISBN : 9780470170380.
2. Tanks and Transport vehicles, Bart H Vanderveen, , Frederic Warne and Co ltd., London, ISBN-13: 9780723218081.

Web Links:

1. https://nexus.talentsprint.com/automated-electric-vehicles-certification-program
2. https://fmttibudni.gov.in/index.php/en/

Automotive & Pedestrian Safety

Course Code: 241ME056

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the different Safety legislations towards safety of typical Automotive Vehicle
- **CO2:** Discuss the various Biomechanics and Simulations aspects against the vehicle accidents
- **CO3:** Evaluate the various vehicle body parts against the Crash worthiness
- **CO4:** Explain the different dynamic vehicle simulation tests
- **CO5:** Evaluate the Pedestrian safety against vehicle hit the pedestrian

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3	3	2	2	3					1
CO2	3	3	3	2	2	3					1
CO3	3	3	3	2	2	3					1
CO4	3	3	3	2	2	3					1
CO5	3	3	3	2	2	3					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Introduction

Introduction to Safety Legislations, Overview of road accidents, Accident avoidance measure like - Human Factors, Comfort and Ergonomics, Acceleration and Braking conditions.

UNIT – II

Biomechanics & Occupant Simulation

Injury tolerance limits, External and internal injuries, Spinal and Chest injuries, Directions of FMVSS 208, EEC directives for frontal and lateral impacts, Body part test devices- Head impact, Torso impact and 3D dummies, Frontal/Rear collision, Rollover and lateral impact

UNIT – III

Vehicle Body considerations

Low Speed Impact, Quasi- Static test requirement - Seat & Seat Belt anchorage points tests as per FMVSS 210, roof strength as per FMVSS 216, Vehicle side structure as per FMVSS 214 procedures.

UNIT – IV

Dynamic Vehicle Simulation Tests

Frontal Collisions - Pole Test, Car-to-Car Crash, Lateral collisions, Rear end collisions and Rollover.

UNIT – V

Pedestrian Safety

Pedestrian hit by front of car, European NCAP Test, Pedestrian Protection test procedure according to 2003/102/EC and 70/156/EC (both Phase I & II)

Text Books:

1. Automotive Vehicle Safety, George A. Peters, Taylor and Francis, Londin and New York, 1st edition, 2019, ISBN : 9780367395872.
2. Recent development in Automotive Safety Technology, SAE International Publication. Editor: Daniel J Helt, 2004, ISBN : 9780768015034.

Reference Books:

1. Automotive Safety Handbook, Ulrich Seiffert and Lothar Wech, SAE International, 2nd edition, ISBN : 9780768017984.
2. The Intelligent Safety of Automobile (Key Technologies on New Energy Vehicles), Jianqiang Wang, Bingbing Nie, Hong Wang, Springer, 2023, 1st edition, ISBN : 978-9819963980.

Web Links:

1. https://skill-lync.com/mechanical-engineering-courses/automotive-safety-standards
2. https://www.nhtsa.gov/vehicle-safety

Minor Stream: Design and Manufacturing

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
241ME057	Plant Layout & Material Handling	FC	2			2	50	50	100	-
241ME059	Additive Manufacturing	IC	3			3	50	50	100	MF - I
241ME060	Composite Materials	IC	3			3	50	50	100	SSP/MP
241ME061	Design for Manufacturing	IC	3			3	50	50	100	MSD
241ME062	Industrial Automation	IC	3			3	50	50	100	MF - I
241ME063	Flexible Manufacturing System	IC	3			3	50	50	100	MF - I
241ME058	Industry 5.0 for Engineers	AC	3			3	50	50	100	-
241ME064	Design of Transmission Systems	AC	2	1		3	50	50	100	MD
241ME065	Advanced Mechanics of Solids	AC	2	1		3	50	50	100	MSD
241ME066	Mechanical Vibrations	AC	2	1		3	50	50	100	DOM
241ME067	Condition Monitoring	AC	3			3	50	50	100	MV
	Total		**30**	**2**		**32**				

Plant Layout & Material Handling

Course Code: 241ME057	L	T	P	C
	2	0	0	2

Course Outcomes:

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

- **CO1:** Identify the suitable plant layout design.
- **CO2:** Explain the concept of facility location.
- **CO3:** Identify the principles of good ventilation systems.
- **CO4:** Implement the concepts of group technology and line balancing in material handling system.
- **CO5:** Explain the usage and principles of material handling equipment.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2					1					
CO2	2					1					
CO3	2	2	1			1				1	
CO4	2	2			3	1					
CO5	2	2				1				1	

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	1	
CO2	1	
CO3	1	
CO4	1	
CO5	1	

UNIT – I

Plant Layout

Introduction of production system, scope, objectives, importance, and types of plant layout, characteristics of a good plant layout, factoring affecting plant layout, procedure of developing a plant layout, installation and evaluation of plant layout, optimum plant layout.

UNIT – II

Plant Location and Site Selection

Introduction to plant location, influence of location on plant layout, plant location selection factors, models for the plant location selection: median model, gravity model, rural, urban, and suburban location of plants, optimum plant location, location theories.

UNIT – III

Working Conditions

Principles of good ventilation, purpose, physiological and comfort level types, local and exhaust ventilation, hood and duct design, air conditioning, ventilation standards, application, purpose of lighting, types, advantages of good illumination, glare and its effect, lighting requirements for various works, standards- housekeeping, principles of 5S.

UNIT – IV

Group Technology & Line Balancing

Definition, objectives, planning, part families and machine cell formation, evaluation of machine cells, types of GT layout, benefits of GT, implementation of GT.

Line Balancing: Definition, heuristic, and analytical methods of balancing the assembly and production line, single and mixed model line balancing, alternatives to line balancing.

UNIT – V

Materials Handling

Definition, scope, objectives, principles, importance, and factors in materials handling problem, analysis of materials handling, types and selection of materials handling equipment, aids, and techniques in material handling equipment selection,time analysis, planning of material flow, advantages of planned material flow, flow planning principles, flow patterns, analysis of material flow.

Text Books:

1. Material Handling Principles and Practice, T. H. Allegri, CBS Publishers & Distributors, 1st Edition, 2019, ISBN: 9788123908403.
2. Automation, Production Systems, and Computer-Integrated Manufacturing, M. P. Groover, Pearson, 4th Edition, 2019, ISBN : 9789332572492.

Reference Books:

1. Introduction to Material Handling, S. Roy, New Age International (P) Ltd, 2nd Edition, ISBN : 9788122440072.
2. Computer Aided Production Management, P.B. Mahapatra, Prentice Hall of India, Prentice-Hall of India Pvt. Ltd, 1st Edition, ISBN : 978-8120317420.

Web Links:

1. https://hmhub.in/equipment-material-management/relationship-operational-layoutmaterial-handling-equipments/
2. https://mbahub.in/?s=facilities+layout+and+material+handling

Industry 5.0 for Engineers

Course Code: 241ME058

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the basic concept of Industry 5.0.
- **CO2:** Explain the concepts of Industrial IOT, IOS and Predictive Analytics
- **CO3:** Explain the cyber physical systems and AI technologies
- **CO4:** Analyse the applications of Industry 5.0 in various sectors
- **CO5:** Analyse case studies on automation and healthcare services

Mapping of Course Outcomes with Program Outcomes: :

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1										
CO2	1	1	1		2						
CO3	1	1	1		2						
CO4	1	3	1		2						
CO5	1	3	1		2						

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Introduction to Industry 5.0

Introduction of Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 5.0, Comparison of Industry 5.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Automation and Transformation Processes.

UNIT – II

Importance of Internet of Things (IOTs)

Introduction to Internet of Things (IoT), Industrial Internet of Things (IIoT), Internet of Services, Fundamental of Predictive Analytics, Smart Logistics, Smart Devices and Products.

UNIT – III

Technology Evolution

Basics of cyber Physical Systems, Process Automations and Collaborative robots, Fundamental to artificial Intelligence, Mobile Computing, Cyber Security, Ethical technology, Responsive and distributed supply chain system, Human-centric and Value-oriented approaches.

UNIT – IV

Technology Implementation and Case Studies

3D printing, Solar energy sector, Healthcare sector, Maintain records related to education, finance, clean bioenergy generation and Intelligent NextG Wireless Networks.

UNIT – V

Case studies on CNC/NC automation - Benefits, challenges, and industry applications., In-house, Healthcare services - Examples of innovations improving patient care and operational efficiency.

Text Books:

1. Uthayan Elangovan, Industry 5.0, "The Future of the Industrial Economy", First Edition, Taylor & Francis, ISBN: 978-1-032-04127-8, 2022.
2. Alessandro Massaro, "Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances", Wiley-IEEE Press, 2021, ISBN: 2021028944.

Reference Books:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, ISBN-13: 978-1484227164
2. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", Springer, ISBN-13: 978-1447121496
3. Hans Bernhard Kief, Helmut Roschiwal, Karsten Schwarz, "The CNC Handbook: Digital Manufacturing and Automation from CNC to Industry 4.0", Industrial Press Inc., U.S. ISBN 0831136367, Nov 2021.
4. Janya Chanchaichujit, Albert Tan, Fanwen Meng, Sarayoot Eaimkhong, "Healthcare 4.0 Next Generation Processes with the Latest Technologies", Palgrave Pivot, 2019,ISBN978-981-13-8113-3.

Web Links:

1. http://www.mqtt.org/
2. https://opcfoundation.org/about/opc-technologies/opc-ua/
3. https://www.ethercat.org/default.htm

Additive Manufacturing

Course Code: 241ME059	L	T	P	C
	3	0	0	3

Course Outcomes:

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

CO1: Summarize the basics of Additive manufacturing technologies

CO2: Explain the methodology to manufacture the products using material and binder jetting

CO3: Apply the methodology to manufacture the products using material extrusion and sheet lamination

CO4: Illustrate powder bed fusion and directed energy deposition Additive manufacturing technologies.

CO5: Explain the applications of Additive manufacturing process in various fields

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2										
CO2	3	2			2	1					
CO3	3	2			2	1					
CO4	3	2			2	1					
CO5	3	2	2		2	1					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Introduction: Basic principle, need, advantages, Challenges in Additive manufacturing (AM), AM Process chain - CAD Model - Input file formats - Generation and Conversion of STL file - File Verification and Repair - Build File Creation - Part Construction - Part Cleaning and finishing, Classification of additive manufacturing processes-Baseline approach, Raw material-based approach and ASTM classification, Materials used in additive manufacturing

UNIT – II

VAT Photo Polymerization of AM process: VAT Photo Polymerization, Material Jetting and Binder Jetting AM technologies: Stereo lithography Apparatus (SLA), Digital Light Projection (DLP), Solid Ground Curing (SGC), Nano Particle Jetting (NPJ), Binder Jetting and Multi Jet Fusion (MJF)processes - Working Principle, Materials, Applications, Advantages and Disadvantages

UNIT – III

Material Extrusion and Sheet Lamination AM technologies: Fused Deposition Modelling (FDM), Contour Crafting (CC), Laminated Object Manufacturing (LOM), – Working principle, Materials, Applications, Advantages and Disadvantages

UNIT – IV

Powder Bed Fusion and Direct Energy Deposition: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM), Laser Engineered Net Shaping (LENS), Wire Arc Additive Manufacturing (WAAM) - Working principle, Materials, Applications, Advantages and Disadvantages

UNIT – V

Additive Manufacturing - Applications: Applications in prototyping, concept models, visualization aids, replacement parts, tooling, jigs & fixtures, moulds, casting, and end-use parts, Industrial Applications in aerospace, automobile, medical, jewellery, sports, electronics, food, construction and architectural, Case studies.

Text Books:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing, Ian Gibson, David W. Rosen, Brent Stucker, Springer, 2nd Edition, ISBN: 9781493921
2. 3D Printing and Additive Manufacturing: Principles and Applications, Chua C.K., and Leong K.F., World Scientific publications, 4th Edition, ISBN : 978-9814571418.

Reference Books:

1. Additive Manufacturing, Amit Bandyopadhyay, Sushmita Bose, CRC Press, 1st Edition, ISBN : 9781482223590.
2. Rapid Prototyping & Manufacturing, Paul F. Jacobs, ASME Press, 1st Edition,ISBN : 9780070324336.
3. Additive Manufacturing Technologies and Applications, P.B.Bagali, V.V.Kamesh, P.S.Ranjit, S.Hangargi, Scientific International Publishing House, 1st Edition, 2022
4. KG Jaya Christiyan, DVSSSV Prasad,KR Senthil Kumar , "Applications of 3D Printing Technology",Scientific International Publishing House, ISBN: 9789356254794, 2022.
5. Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants and Custom Jewellery, John O. Milewski, Springer, 1st Edition, ISBN : 9783319863481.

Web Links:

1. https://www.3dprintingindustry.com
2. https://www.reprap.org
3. https://www.all3dp.com

Composite Materials

Course Code: 241ME060

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Classify the composites with types of fibers and matrices, and applications of composites
- **CO2:** Evaluate mechanical properties of composite materials using macro and micro mechanics
- **CO3:** Develop suitable Metal Matrix Composites
- **CO4:** Explain Polymer Matrix Composites with applications
- **CO5:** Discuss various Ceramic Matrix Composites for high temperature applications

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3					1					
CO2	2	3			2						
CO3	3		2			1					
CO4	2		2	2		3					
CO5	3		1	2		2					

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Introduction to composites

Fundamentals of composites - need for composites – enhancement of properties - classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) – Types of Reinforcement and Matrix, Carbon and Glass. Reinforcements – particles – fibres. Effect of reinforcement - volume fraction – rule of mixtures

UNIT – II

Evaluation of Mechanical Properties

Micromechanical analysis of lamina –Volume and mass fraction, density and void content – Evaluation of Elastic modulii, Ultimate strength of unidirectional lamina. Macromechanical analysis of laminates – Laminate code, Stress strain relations – Inplane and Flexural modulu.

UNIT – III

Metal Matrix Composites (MMC)

Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Processing of MMC – powder metallurgy process- diffusion bonding – stir casting – squeeze casting, In-situ reactions-Interface-

measurement of interface properties applications of MMC in aerospace, automotive industries

UNIT – IV

Polymer Matrix Composites

Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibres – rovings – woven fabrics – non woven random mats – various types of fibres. Processing of thermoset matrix composites, thermoplastic matrix composites, structure and properties, structural defects, mechanical properties and applications

UNIT – V

Ceramic Matrix Composites (CMC)

Engineering ceramic materials – properties – advantages – limitations – monolithic ceramics - need for CMC – ceramic matrix - various types of ceramic matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride – reinforcements – particles- fibres, whiskers. Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing), applications of CMC in aerospace, automotive industries- Carbon /carbon composites

Text Books:

1. Composite Material Science and Engineering, Krishan K , Chawla, Springer, 2nd Edition, ISBN 9788132233442 : .
2. Composite Materials: Engineering and Science , Mathews F. L. and Rawlings R. D, Chapman and Hall, London, England, 1st Edition, ISBN : 9781855734739.

Reference Books:

1. Composite Materials Science and Applications, Deborah D.L. Chung, Springer London Ltd, 2nd Edition, ISBN9781848828308 : .
2. Composite Materials Design and Applications, Daniel Gay, Suong V. Hoa & Stephen W. Tsai, CRC Press, 1st Edition, ISBN : 9781587160844.

Web Links:

1. https://nptel.ac.in/courses/112104229
2. https://www.coursera.org/learn/ceramics-and-composites.

Design for Manufacturing

Course Code: 241ME061	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Outline the appropriate design for economical production and select the materials.
- **CO2:** Select between various casting and metal joining processes
- **CO3:** Apply a systematic understanding of knowledge in the field of metal casting and forging.
- **CO4:** Fabricate basic parts and assemblies using powered and non –powered machine shop equipment in conjunction with mechanical documentation.
- **CO5:** Integrate the knowledge of compliance analysis and interference analysis for assembly and environment.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	2			1					1
CO2	2	1	2			1					1
CO3	2	2	2			1					1
CO4	2	2	2		2	1					1
CO5	2	2	2		2	1					1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Introduction

Design philosophy – steps in design process – general design rules for manufacturability – basic principles of designing for economical production – creativity in design, application of linear & non-linear optimization techniques. Material selection interrelationship with process selection – process selection charts.

UNIT – II

Metal casting and Metal joining:

Appraisal of various casting processes, selection of casting process, - general design considerations for casting – casting tolerances – use of solidification.

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines – pre and post treatment of welds – effects of thermal stresses in weld joints – design of brazed joints. Simulation in casting design – product design rules for sand casting.

UNIT – III

Extrusion and sheet metal work: Design guidelines for extruded sections - design principles for punching, blanking, bending, and deep drawing – Keeler Goodman forming line diagram – component design for blanking.

Forging: Design factors for forging – closed die forging design – parting lines of dies – drop forging die design – general design recommendations.

UNIT – IV

Machining process: Overview of various machining processes – general design rules for machining - dimensional tolerance and surface roughness – design for machining – ease – redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.

UNIT – V

Assembly: Compliance analysis and interference analysis for the design of assembly – design and development of features for automatic assembly – liaison diagrams.

Environment: Introduction to environment; motivations for environment principles of environment- eco-efficiency, product life cycle perspective, environment tools and processes, environment design guidelines.

Text Books:

1. Product Design and Manufacturing, A K Chitale and R C Gupta, PHI, New Delhi, 5th edition, ISBN : 9788120342828.
2. George E Deiter, “Engineering Design”, McGraw Hill International, 5th edition, ISBN9780073398143 : .

Reference Books:

1. Product design for Manufacture and Assembly, Boothroyd G, First Edition, Marcel Dekker Inc, New York, ISBN : 9780824791766.
2. Materials and Design - the art and science of material selection in product design, M F Ashby and K Johnson, Butterworth-Heinemann, 3rd edition, ISBN: 9780080982052.

Web Links:

1. NPTEL :: Mechanical Engineering - Design For Manufacturing
2. Manufacturing process selection and Design for manufacturing | Udemy

Industrial Automation

Course Code: 241ME062

L	T	P	C
3	0	0	3

Course Outcomes:

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

- **CO1:** Comprehend the need for industrial process automation.
- **CO2:** Differentiate various types of automation systems and components of automation.
- **CO3:** Develop automation system for manufacturing and process industries
- **CO4:** Perform supervisory control and data acquisition
- **CO5:** Develop skills on wireless sensor networks and the industrial networking

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3				2		1				1
CO2	2	3			2		1				1
CO3	3	2	3		2		1				1
CO4	2				2		1				1
CO5	3				2		1				1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	3	
CO4	3	
CO5	3	

UNIT – I

Basic Concepts

Introduction of Mechanization and Automation, Classification and Strategies of Automation, Reasons for and Arguments against Automation. Mechanical, Electrical, Hydraulic, and Pneumatic Devices and Controls.

UNIT – II

High Volume Manufacturing

Automated Flow Lines, Types of Automatic Transfer Mechanisms, Design and Fabrication Considerations, Analysis of Automated Flow Lines.

UNIT – III

Assembly Automation

Assembly Systems and their Types, Manual Assembly Lines and Line Balancing, Automated Assembly Lines and their Types, Automatic Assembly Transfer Systems, Automatic Feeding and Orienting Devices- Vibratory and Mechanical Feeders - types, Orientation of Parts, Performance and Economics of Assembly Systems, Feasibility Study for Assembly Automation.

UNIT – IV

Supervisory Digital Control (SCADA)

Computer Process interface for Data Acquisition and control – Computer control loops. – Supervisory Digital Control (SCADA) - introduction and brief history of SCADA – SCADA Hardware and software – Landlines for SCADA – use of modems in SCADA – SCADA with LAN

UNIT – V

Intelligent Systems

Fuzzy inference technique, Artificial neural network technique, Pneumatic and electro pneumatic system, Hydraulic and electrohydraulic system - Micro controllers and processors, PLC Programming and flow control.

Text Books:

1. Programmable Logic Controllers: Principles and Applications, John W. Webb, Ronald A. Reis, Pearson, 4th edition, ISBN : 9780136794080.
2. Distributed Computer Control for Industrial Automation, Poppovik Bhatkar, Dekkar Publications, 1st edition, ISBN : 9780824781187.

Reference Books:

1. Automation, Production Systems, and Computer-Integrated Manufacturing, 4e by Mikell P. Groover, ISBN-13-978-9332572492.
2. PC Interfacing and Data Acquisition Techniques for Measurement, Instrumentation and Control, Kevin James, Elsevier, 1st edition, 2011, ISBN: 9789380931517.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc22_me50/preview
2. https://onlinecourses.nptel.ac.in/noc22_me50/preview

Flexible Manufacturing System

Course Code: 241ME063	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Comprehend the need for a Flexible Manufacturing System
- **CO2:** Differentiate several types of Machining center
- **CO3:** Implement the concepts of Manufacturing systems
- **CO4:** Explain the basic concepts of Industry 4.0
- **CO5:** Identify Material Handling System in FMS

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3				2		1				1
CO2	2	3			2		1				1
CO3	3	2	3		2		1				1
CO4	2	2			2		1				1
CO5	3	2	2		2		1				1

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

FMS Introduction and Description

Limitations with conventional manufacturing, Flexible Manufacturing System (FMS) Need -Definition, Basic Component, Significance -General layout and configuration- Principle Objectives, Benefits and limitations, Area of Application in Industries, Hardware, Software, CIM Technology, Hierarchy of CIM, FMS Justification.

UNIT – II

Turning and Machining Centres

Introduction, Types, Construction and Operation Performed on Turning Center, Automated Features and Capabilities, Advantages and Disadvantages of Vertical and Horizontal Machining Centres, Pallet and Part Loading and Programming Options in Machining Centres, Importance of Cleaning and Deburring in Automated Manufacturing. Concepts of Mechanization, Automation and Integration.

UNIT – III

Manufacturing systems: Single Station Manufacturing Cells, Manual Assembly Lines, Concepts of scheduling and line balancing, Group Technology & Cellular Manufacturing , Automated Assembly Systems

Manufacturing philosophy: Just in time (JIT) manufacturing, Kanban system, Agile Manufacturing, Lean manufacturing, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems and Agent-Based Manufacturing Systems

UNIT – IV

Industry 4.0: Introduction - Industry 4.0 – Smart manufacturing: Smart design, smart machining, smart monitoring, smart control, smart scheduling - Internet of Things - Industrial Internet of Things - Framework: Connectivity devices and services - Intelligent networks of manufacturing - Cyber physical systems -Machine to Machine communication- case studies, Introduction to Industry 5.0

Automated assembly and Automated operation planning for layered manufacturing processes.

UNIT – V

Automated Material Movement and Storage System

Introduction, Types of AGV -working principle, Advantages, Limitation and AGV Guide path Tool Management, Tool Strategies, Tool Preset, Identification and Data Transfer, Tool Monitoring and Fault Detection, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet, Queuing Carrousels and Automatic Work Changers, Coolant and Chip Disposal and Recovery system. FMS Installation and Implementation

Text Books:

1. Flexible Manufacturing Cells and System, William W. Luggen, Prentice Hall of Inc New Jersey, ISBN : 9780133217384.
2. Flexible manufacturing, David J. Parrish Butterworth-Heinemann Ltd., ISBN : 9780750610117.

Reference Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, M. P. Groover, Prentice Hall, 4th edition, ISBN : 9789332572492.
2. Flexible Manufacturing System, H. K. Shivanand, M. M. Benal, V. Koti, New Age Publication, 1st edition, ISBN : 9789386070227.

Web Links:

1. https://nptel.ac.in/courses/110106044
2. www.ignou.ac.in/upload/UNIT6-55.pdf

Industry 5.0 for Engineers

Course Code: 241ME058	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the basic concept of Industry 5.0.
- **CO2:** Explain the concepts of Industrial IOT, IOS and Predictive Analytics
- **CO3:** Explain the cyber physical systems and AI technologies
- **CO4:** Analyse the applications of Industry 5.0 in various sectors
- **CO5:** Analyse case studies on automation and healthcare services

Mapping of Course Outcomes with Program Outcomes: :

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	1										
CO2	1	1	1		2						
CO3	1	1	1		2						
CO4	1	3	1		2						
CO5	1	3	1		2						

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Introduction to Industry 5.0

Introduction of Various Industrial Revolutions, Digitalisation and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 5.0, Comparison of Industry 5.0 Factory and Today's Factory, Trends of Industrial Big Data and Predictive Analytics for Smart Business Automation and Transformation Processes.

UNIT – II

Importance of Internet of Things (IOTs)

Introduction to Internet of Things (IoT), Industrial Internet of Things (IIoT), Internet of Services, Fundamental of Predictive Analytics, Smart Logistics, Smart Devices and Products.

UNIT – III

Technology Evolution

Basics of cyber Physical Systems, Process Automations and Collaborative robots, Fundamental to artificial Intelligence, Mobile Computing, Cyber Security, Ethical technology, Responsive and distributed supply chain system, Human-centric and Value-oriented approaches.

UNIT – IV

Technology Implementation and Case Studies

3D printing, Solar energy sector, Healthcare sector, Maintain records related to education, finance, clean bioenergy generation and Intelligent NextG Wireless Networks.

UNIT – V

Case studies on CNC/NC automation, In-house, Healthcare services.

Text Books:

1. Uthayan Elangovan, Industry 5.0, "The Future of the Industrial Economy", First Edition, Taylor & Francis, ISBN: 978-1-032-04127-8, 2022.
2. Alessandro Massaro, "Electronics in Advanced Research Industries: Industry 4.0 to Industry 5.0 Advances", Wiley-IEEE Press, 2021, ISBN: 2021028944.

Reference Books:

1. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 2016.
2. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. Hans Bernhard Kief, Helmut Roschiwal, Karsten Schwarz, "The CNC Handbook: Digital Manufacturing and Automation from CNC to Industry 4.0", Industrial Press Inc., U.S. ISBN 0831136367, Nov 2021.
4. Janya Chanchaichujit, Albert Tan, Fanwen Meng, Sarayoot Eaimkhong, "Healthcare 4.0 Next Generation Processes with the Latest Technologies", Palgrave Pivot, 2019,ISBN978-981-13-8113-3.

Web Links:

1. http://www.mqtt.org/
2. https://opcfoundation.org/about/opc-technologies/opc-ua/
3. https://www.ethercat.org/default.htm

Design of Transmission Systems

Course Code: 241ME064	L	T	P	C
	2	1	0	3

Course Outcomes:

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

- **CO1:** Utilize principles for designing belt transmissions, chain drives, and wire ropes, including material selection and load capacity considerations.
- **CO2:** Apply lubrication principles to design friction bearings, analyzing stability and heat balance.
- **CO3:** Develop designs for spur and helical gears considering speed ratios, fatigue strength, and tooth stresses, and analyze forces in helical and bevel gear drives.
- **CO4:** Explain and apply principles for designing multispeed gearboxes, including kinematic layout and speed diagrams.
- **CO5:** Examine and design various types of clutches and brakes, considering factors like uniform pressure, wear, and thermal effects.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2		2							
CO2	3		2		2						
CO3		2	3		3						
CO4		1	3			3					
CO5		1	3	2		2			3		

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	
CO2	3	
CO3	2	
CO4	3	
CO5	2	

UNIT – I

Design of Flexible Mechanical Drives

Introduction to flexible drives – Design of belt transmissions. Geometry. Construction details and assembly. Types of failure– Ratio of Tensions – Belt materials – Design procedure– Design of chain drives and sprockets – Load carrying capacity – Design of wire ropes – construction and designation – Selection procedure.

UNIT – II

Design of Bearings:

Conditions of proper lubrication, Mechanism of dry friction, Petroff's law, Assumptions involved in Petroff's law, Hydrodynamic lubrication, Practical examples, hydrodynamic conditions in a bearing, McKeey's equation, Thick and thin film lubrications, Stability of lubrication, Bearing modulus, Heat balance in a journal bearing. Rolling contact bearings-rated load, dynamic capacity calculation. Bearing selection.

UNIT – III

Design of Gears:

Gear materials - Design of straight tooth spur & helical gears based on speed ratios, number of teeth, Fatigue strength, Factor of safety, strength, and wear considerations.

Force analysis –Tooth stresses - Dynamic effects - Helical gears – Module - normal and transverse, Equivalent number of teeth – forces. – Stresses on bevel gear tooth – Design of bevel gear drive using manufacturer's catalogue – Equivalent number of teeth – Force analysis on bevel gear – Design based on beam strength and wear

UNIT – IV

Design of Multispeed Gearbox:

Introduction to multispeed gearbox – Components of speed reduction unit – Principles for optimum gearbox design – Progression ratio – Construction of kinematic layout and speed diagram – Centre distance calculation – Selection of number of teeth. Design of multi-speed gearbox for machine tool applications, Variable speed gearbox, Fluid Couplings, and Torque Converters for automotive applications

UNIT – V

Design of Clutches and Brakes :

Design of disc or plate clutches – Cone clutch – Centrifugal clutch – Design of Block brakes with short and long shoe – Internal expanding shoe brakes – Band brakes – Disc brakes.

Text Books:

1. Design of machine elements, V.B.Bhandari, McGrawHill Publications, 5th Edition, 2020, ISBN : 9789390177479.
2. Mechanical Engineering Design, J Shigley, McGrawHill Publications, 10th Edition, ISBN : 9780073398204.

Reference Books:

1. Design Data, P.S.G. College of Technology, Coimbatore, 2020, ISBN : 9788192735504.

Web Links:

1. https://archive.nptel.ac.in/courses/112/106/112106137/
2. https://archive.nptel.ac.in/courses/112/105/112105125/

Advanced Mechanics of Solids

Course Code: 241ME065	L	T	P	C
	2	1	0	3

Course Outcomes:

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

- **CO1:** Analyze the biaxial stresses using graphical and analytical methods
- **CO2:** Find the bending and shear stresses in beams of various cross sections
- **CO3:** Find the deflection of beams by Double integration method , Macaulay's method and Conjugate beam method
- **CO4:** Find the stresses and deformations in shafts and springs using torsion formulae
- **CO5:** Analyze the cylinders and columns using deformation and buckling formulae

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	2		1						2
CO2	3	2	2		1						2
CO3	3	2	2		1						2
CO4	3	2	2		1						2
CO5	3	2	2		1						2

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Bi-axial Stresses

Introduction – Stresses on an inclined section of a bar under axial loading – compound stresses – Normal and tangential stresses on an inclined plane for biaxial stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses and strain, Strain rosette – Principal stresses and strains – Analytical and graphical solutions. Theories of failure.

UNIT – II

Stresses in beams

Introduction to theory of bending – Assumptions – Bending equation - Neutral axis – Determination of bending stresses – section modulus of rectangular and circular sections (Solid and Hollow), I, T, Angle and Channel sections – Design of simple beam sections, **Shear Stresses:** Derivation of formula – Shear stress distribution across various beams sections like rectangular, circular, triangular, I, T sections

UNIT – III

Deflection of beams

Deflection of beams by Double integration method – Macaulay's method – Area moment theorems for computation of slopes and deflections in beams – Conjugate beam method.

UNIT – IV

Torsion

Introduction to Torsion – derivation of shear strain – Torsion formula – stresses and deformations in circular and hollow shafts –Parallel and series shafts – shafts fixed at the both ends, stresses in springs

UNIT – V

Thin and Thick Cylinders, Columns

Thin cylinders and shells – deformation of thin cylinders and shells; Thick Cylinders, Shrink fits, Compounding. Theory of columns – Long column and short column - Euler's formula – Rankine's formula

Text Books:

1. Strength of Materials ,Rattan S. S., McGraw Hill Education, 3rd edition, ISBN : 9789385965517.
2. Mechanics of Materials ,James M. Gere, Barry J. Goodno, , Cengage Learning India Pvt. Ltd , 9th Edition, 2019, ISBN : 9789355737847.

Reference Books:

1. Mechanics of Materials, Russell C. Hibbeler, Pearson Education, 9th Edition; 2018, ISBN : 9789332584037.
2. Mechanics of Materials, Ferdinand P. Beer, E. Russell Johnston, John T. DeWolf, David F. Mazurek, Sanjeev Sangh, McGraw Hill Education, 8th Edition, 2020, **ISBN-13**: 978-1260571387.

Web Links:

1. https://ocw.mit.edu/courses/1-050-solid-mechanics-fall-2004/
2. https://onlinecourses.nptel.ac.in/noc22_ce46/preview

Mechanical Vibrations

Course Code: 241ME066	L	T	P	C
	2	1	0	3

Course Outcomes:

At the end of the Course, Student will be able to:

CO1: Analyze the free vibrations of single degree of freedom systems.

CO2: Derive the equations of motion for vibrating systems subjected to harmonic excitation and general forcing conditions.

CO3: Analyze the vibrations of two degree of freedom systems and principles of vibration measuring instruments.

CO4: Formulate the equations of motion for free and forced vibrations of multi degree of freedom systems.

CO5: Formulate the equations of motion for free and forced vibrations of continuous systems.

Mapping of course outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2								
CO2	3	2	2								
CO3	3	2	2		2	1					
CO4	3	2	2								
CO5	3	2	2								

Mapping of course outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	2	
CO2	2	
CO3	2	
CO4	2	
CO5	2	

UNIT – I

Fundamentals of Vibration: Classification of vibration-Vibration analysis procedure-Spring elements - Mass or Inertia elements- Damping Elements - Harmonic Analysis.

Free Vibration of Single-Degree of freedom Systems: Equation of motion for undamped and damped translational and torsional systems - Viscous damping - Coulomb damping - Hysteretic damping –Response and stability of systems.

UNIT – II

Harmonically Excited Vibration: Equation of motion and response of an undamped damped systems under harmonic force - Quality Factor and Bandwidth - Response of a damped system under rotating unbalance- Self-Excitation and Stability Analysis.

Vibration Under General Forcing Conditions: Response under a general periodic force – First order and Second order systems-Response under a nonperiodic force - Convolution Integral - Response Spectrum - Laplace Transform- Numerical methods.

UNIT – III

Two Degree of freedom Systems: Equations of motion for free and forced vibration of damped and undamped systems - Coordinate Coupling and Principal Coordinates -Self-Excitation and Stability Analysis -Solutions Using Laplace Transform.

Vibration Measurement and Applications: Transducers-Vibration Pickups- Frequency measuring instruments-Vibration Exciters- Dynamic testing of machines and structures - Experimental modal analysis-Machine condition monitoring and diagnosis.

UNIT – IV

Multi degree of freedom Systems: Equations of motion for free and forced vibration of damped and undamped systems- Influence Coefficients - Potential and Kinetic Energy Expressions in Matrix Form - Generalized Coordinates and Generalized Forces - Eigenvalue Problems.

UNIT – V

Continuous Systems: Transverse Vibration of a String or Cable -Longitudinal Vibration of a Bar-Torsional Vibration of a Shaft -Lateral Vibration of Beams-Principle of orthogonality-Classical and energy methods by Rayleigh, Ritz and Gelerkin-Torsional vibrations of shafts-Critical speeds with and without damping-Secondary critical speed.

Text Books:

1. Mechanical Vibrations, G.K.Grover, Nemchand publishers, 8th Edition, ISBN : 9788185240565.
2. Mechanical Vibrations, Singiresu S Rao, Pearson education, 5th Edition, ISBN : 9780132128193.

Reference Books:

1. Theory of Vibration, W.T., Thompson, CBS Publishers, 5th Edition, ISBN : 9788131704820.
2. Vibration: Fundamentals and Practice, Clarence W. de Silva , CRC Press LLC,2nd Edition, ISBN : 9780849318085.
3. Elements of Vibration analysis, L. Meirovich, Tata Mc-Grawhill, 2nd Edition, ISBN : 9780070413429.

Web Links:

1. https://archive.nptel.ac.in/courses/112/103/112103111/
2. https://archive.nptel.ac.in/courses/112/107/112107212/

Condition Monitoring

Course Code: 241ME067	L	T	P	C
	3	0	0	3

Course Outcomes:

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

- **CO1:** Explain the principles and importance of condition monitoring and preventive maintenance.
- **CO2:** Identify various sensors and signal conditioning techniques for condition monitoring.
- **CO3:** Plan data acquisition and signal processing methods for effective condition monitoring.
- **CO4:** Utilize machine learning techniques for advanced condition monitoring and predictive maintenance.
- **CO5:** Examine real-world applications and case studies of condition monitoring across various industries.

Mapping of Course Outcomes with Program Outcomes:

CO/PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3		2							
CO2	3	1		1	3						
CO3		1	3	1	3						
CO4		1	3	1	3						
CO5		1		1	3	2			2		

Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
CO1	3	2
CO2	3	3
CO3	2	3
CO4	2	3
CO5	2	3

UNIT – I

Introduction

Overview of condition monitoring and the need for reliable operation of equipment in a system, causes of failure, preventive maintenance concepts Structural Health Monitoring (SHM) – Advantages & Challenges. Machinery Fault Diagnosis - Principles, Fault Diagnostics and Prognostics.

UNIT – II

Sensors and Signal Conditioning Techniques

Vibration Monitoring Accelerometers, Types. Temperature Monitoring – Thermocouple, RTD (Resistance Temperature Detector), Infrared Thermography. Fiber Optic Sensors, NDT (Non-Destructive Testing) – Eddy Current Testing.

UNIT – III

Smart Sensing for Condition Monitoring

Data Acquisition Systems, Application of various signal processing methods – Time domain analysis, Frequency domain analysis, non-stationary signal analysis.

UNIT – IV

Machine Learning (ML) for Condition Monitoring

Introduction, Review of Linear Algebra, Logistic Regression, Regularization, Neural Networks – Representation and Learning, Machine Learning System Design, Support Vector Machines, Unsupervised Learning, Dimensionality Reduction, Anomaly Detection. Application to Condition Monitoring.

UNIT – V

Applications & Case Studies

Future of Condition-based Monitoring – SHM & Rotating Machinery, Railway – Noise and Vibration Monitoring, Ball indentation testing, Crack Detection in Composites (Aerospace structures), Condition Monitoring in – Agriculture, Biomedical, Food Processing & Packaging, Pipelines and Piping.

Text Books:

1. Vibration-Based Condition Monitoring –Industrial,Aerospace and Automotive applications, Robert Bond Randall , John Wiley & Sons Ltd, 1st edition, ISBN : 9780470747858.
2. Structural Health Monitoring: Current Status and Perspectives, Stanford University Fu-Kuo Chang, ISBN : 9781566766050.

Reference Books:

1. Machine Learning Yearning ,S.Sridhar, M Vijayalakshmi, ISBN 13-978-0190127275
2. Machinery Condition Monitoring Principles and Practices, Amiya Ranjan Mohanty, Taylor and Francis, CRC Press, 1st edition, ISBN : 9781138748255.

Web Links:

1. https://onlinecourses.swayam2.ac.in/nou21_me10/preview
2. https://info.deeplearning.ai/machine-learning-yearning-book#MYL-form