Dr. Babasaheb Ambedkar Technological University

(Established as a University of Technology in the State of Maharashtra)
(under Maharashtra Act No. XXIX of 2014)
P.O.: Lonere, Dist.: Raigad, Pin 402 103, Maharashtra.
Telephone and Fax. : 02140 - 275142
www.dbatu.ac.in

Course Structure and Contents

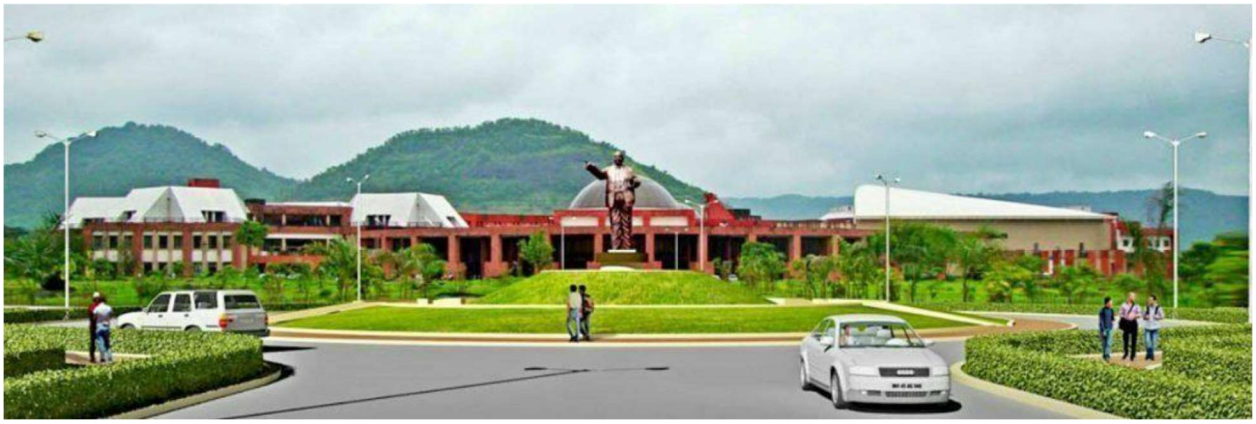
for

M. Tech. in Automotive Technology

(For Affiliated Institutes Only)

Syllabus as per the guidelines of National Education Policy 2020

To be implemented from Academic Year 2024-25.



Vision

The vision of the Department is to achieve excellence in teaching, learning, research and transfer of technology and overall development of students.

Mission

Imparting quality education, looking after holistic development of students and conducting need- based research and extension activities.

Programme Educational Objectives (PEOs)

No.	PEO
PEO1	To train the students with in-depth and advanced knowledge to become professional and capable of identifying, analyzing and solving complex problems in the areas of automotive technology.
PEO2	To enable post graduates to carry out innovative and independent research work, disseminate the knowledge in Academia/Industry/Research Organizations to develop systems and processes in the related field.
PEO3	To prepare the students to exhibit a high level of professionalism, integrity, effective communication skills and environmental and social responsibility.
PEO4	To provide an academic environment that gives adequate opportunity to the students to cultivate life-long independent learning abilities for their successful professional careers.

Programme Outcomes (POs)

At the end of the program, the students will be able to:

No.	PO
PO1	Acquire, demonstrate and apply advanced knowledge in the area of automotive technology
PO2	Identify problems in the field of automotive engineering, formulate them and solve by using advanced techniques.
PO3	Conduct independent research and generate new knowledge for the benefit of community, society Industry and country.
PO4	Apply various numerical methods, advanced software and engineering tools to model, analyze and solve manufacturing engineering problems.
PO5	Work effectively in interdisciplinary teams for solving real life problems in the related field.
PO6	Apply engineering and scientific principles for the effective management of automotive systems.
PO7	Effectively communicate through technical reports, presentations and scientific publications with the engineering community as well as society at large.
PO8	Demonstrate traits of management in handling engineering projects, related finance, and coordinate with workforce towards achieving goals.
PO9	Demonstrate high level of professional and intellectual integrity, ethics of research and scholarly standards.
PO10	Examine critically the outcomes of one's actions and make corrective measures subsequently.
PO11	Demonstrate the ability to work in team in the laboratory in achieving multidisciplinary tasks required for the project.
PO12	Engage in life-long reflective and independent learning with high level of enthusiasm and commitment.

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Abbreviations

PEO : Program Educational Objectives
PO : Program Outcomes
CO : Course Outcomes
L : No. of Lecture hours (per week)
T : No. of Tutorial hours (per week)
P : No. of Practical hours (per week)
C : Total number of credits
PCC : Professional Core Course
OEC : Open Elective Course
PEC : Professional Elective Course
AC : Audit Course
AEC : Ability Enhancement Course
VEC : Vocational Education Course
IKS : Indian Knowledge Society
MDM : Multidisciplinary Minor

M. Tech. Automotive Technology
Curriculum In-line with NEP 2020 guidelines
(Effective from AY 2024-25)

Semester - I											
Course Category	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**	**CA**	**MSE**	**ESE**	**PR/ OR**	**Total**
PCC	12630PC101	Automotive Systems	3	1	-	4	20	20	60	--	100
PCC	12630PC102	Vehicle Dynamics	3	1	-	4	20	20	60	--	100
PCC	12630PC103	Automotive Materials	3	1	-	4	20	20	60	--	100
PEC	12630PE104	Program Elective-I	3	-	-	3	20	20	60	--	100
PEC	12630PE105	Program Elective-II	3	-	-	3	20	20	60	--	100
PCC	12630PC106L	PG Lab-I	-	-	2	1	60	--	--	40	100
ELC	12630SE107	Seminar	-	-	2	1	40			60	100
Audit Course	12630AU108	Stress Management	2	-	-	-	20	20	--	--	40
Total			**17**	**3**	**4**	**20**	**220**	**120**	**300**	**100**	**740**

Semester - II											
Course Category	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**	**CA**	**MSE**	**ESE**	**PR/ OR**	**Total**
PCC	12630PC201	Alternative Fuels and Emissions	3	1	-	4	20	20	60	--	100
PCC	12630PC202	Advanced Automotive Engine Technology	3	1	-	4	20	20	60	--	100
PCC	12630PC203	Hybrid and Electric Vehicles	3	1	-	4	20	20	60	--	100
PEC	12630PE203	Program Elective-III	3	-	-	3	20	20	60	--	100
OE	12630OE204	Open Elective I	3	-	-	3	20	20	60	--	100
PCC	12630PC205L	PG Lab-II	-	-	2	1	60	--	--	40	100
ELC	12630MP206	Mini-Project	-	-	2	1	40	--	--	60	100
AEC/VEC/IKS	12630AE207	IKS Bucket	2	-	-	2	20	20	60	--	100
Total			**16**	**2**	**04**	**22**	**220**	**120**	**300**	**100**	**740**

Semester - III											
Course Category	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**	**CA**	**MSE**	**ESE**	**PR/ OR**	**Total**
PCC		Electric Vehicle Structure Design	3	-	-	3	20	20	60	--	100
OE	12630OE301	Open Elective II	3	-	-	3	20	20	60	--	100
MDM	12630MD302	Multidisciplinary Minor	3	-	-	3	20	20	60	--	100
PCC	12630PR304	Project Stage I	-	-		10	50	--	--	50	100
Total			**9**	**1**	**-**	**19**	**110**	**60**	**180**	**50**	**400**

Semester - IV											
Course Category	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credit**	**CA**	**MSE**	**ESE**	**PR/ OR**	**Total**
PCC	12630PR401	Project Stage II	-	-		20	100	--	--	100	200
Total			**-**	**-**		**20**	**100**	**--**	**--**	**100**	**200**

Note:

1. *Students can complete 40% of the courses from SWAYAM /NPTEL/Coursera/ from Institutes with MoU signed by the university.*
2. *Existing passing rules will be applicable.*

Credit Distribution				
SEM I	**SEM II**	**SEM III**	**SEM IV**	**Total Credits**
20	**22**	**19**	**20**	**81**

Abbreviations: PCC (Programme Core Course), PEC (Programme Elective Course), ELC (Experiential Learning Courses), OE (Open Elective), AEC (Ability Enhancement Courses), VEC (Value Education Courses), IKS (Indian Knowledge System), MDM (Multidisciplinary Minor).

	Program Elective -I
A)	Automotive Electronics
B)	Vehicle Maintenance and Diagnostics
C)	Automotive HVAC

	Program Elective -II
A)	Vehicle Aerodynamics
B)	Finite Element Method
C)	Automotive Safety and Lighting

	Program Elective -III
A)	Computational Numerical Methods
B)	Vehicle Crashworthiness
C)	Industry 4.0

	Open Elective I
A)	IoT Technology
B)	Entrepreneurship
C)	Research Methodology

	Open Elective II
A)	Mechatronics and Robotics
B)	Intellectual Property & Rights
C)	Principles of Economics

	Multidisciplinary Minor
A)	Design of Mechatronic Systems
B)	Ethical Hacking
C)	Sustainable Power Generation Systems

IKS Bucket

	Indian Knowledge System (IKS)
A)	Indian Knowledge System (IKS): Concepts and Applications in Engineering
B)	Indian Knowledge System (IKS): Humanities and Social Sciences

Automotive Systems

12630PC101	Automotive Systems	Elective II	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-requisites: Machine Design, CAD-CAM.

Course Objectives:

1. To enable students to understand considerations in the design of automotive body and chassis systems.
2. To enable students to apply the knowledge for designing clutch and gearbox.
3. To enable students to apply the knowledge for designing the steering system of vehicles.
4. To enable students to apply the knowledge for designing the braking system of a vehicle.

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

CO1:	Understand the types, constructional details, design considerations in Automotive body and Chassis systems.
CO2:	Understand and design the automotive clutch and gearbox with all considerations.
CO3:	Design the steering system of automobile for true rolling condition.
CO4:	Understand recent advancements in suspension systems and analyze the effect of suspension parameters on stability of vehicle.
CO5:	Design the braking system of automobile under dynamic condition.

Mapping of course outcomes with program outcomes

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		2								1
CO2	2	2	3	2					1	1		2
CO3	2	2	3	2					1	1		2
CO4			1	2		1			1	1		1
CO5	2	3	3	2					2	1		2

Unit I Automotive Body and Types of Chassis. (07 Hours)

Car Body: Types, Constructional details, material, design criteria, Bus body: Types, constructional details, material, bus body layout, Commercial vehicle body: Types of commercial vehicles, Dimensions of driver's seat relation to controls, Drivers cab design. Chassis: Types of Chassis layout, Power Plant location and drive, Types of vehicle frames, Loads acting on frame, Constructional and design considerations in frame, materials for frames, Testing of frames. Integral construction, Monocoque, Back bone.

Unit II Automotive Clutch: (06 Hours)

Necessity of clutch in an automobile, Types of friction clutches: Single plate, Multi plate, Cone, Centrifugal, Hydraulic clutch, Vacuum operated clutch. Adjustment of clutch causes of troubles in Clutch, Design considerations and material, Introduction of Fluid Coupling: Working, Constructional details, Advantages and Limitations.

Unit III Automotive Gearbox: (06 Hours)

Road Loads, Need of Gearbox, Types and Constructional details: Sliding-mesh gear box, Constant-mesh gear box, synchromesh gear box, transfer case, overdrive. Automatic Transmission System, Semi-Automatic Transmission System. Design of gear box – Selection of 4 or 6 or 8 speed gear box for a vehicle. Selection of gear ratio, Selection of number of teeth for a given gear ratio. (Numericals)

Unit IV Steering System. (06 Hours)

Necessity of steering system in an automobile, Front wheel geometry and its significance: Castor, Camber, King pin inclination, Toe-in, Toe-out, Ackermann and Davis steering system, Steering linkages, Steering Gearbox, Concept of Understeer, Oversteer, Neutral Steer, Conditions for true rolling motion of wheels, Types of steering systems, Four-wheel steer, Steer by wire. (Numericals on Ackermann angle)

Unit V Suspension System: (10 Hours)

Function of suspension system, Types of suspension system, dependent suspension, independent suspension, electronic control pneumatic suspension system, Active suspension system, Function of dampers, types of damping, shock absorbers, bose suspension, Suspension Roll centers, Suspension design considerations, Constructional details of spring, leaf spring, torsion bar.

Braking System:

Classification of brakes: Drum brakes and Disc brakes, Constructional details, theory of braking, concept of dual brake system, Anti-lock braking system , Electronic brake force distribution, parking brake, vacuum assisted system, air brake system, retarded engine brakes, Electronic stability control. Braking System design considerations. (Numericals on Brake Design)

Textbooks:

1. Crouse W.H, “Automotive chassis and body” (1971), McGraw-Hill, New York.
2. Gento., Giancarlo., Morello., “The Automotive chassis”, (2009), Springer.
3. R.K. Rajput, “A Text–Book of Automobile Engineering”,(2010),Laxmi Publications Private Limited

Reference Books:

1. Naunheimer, H., Bertsche, B., Ryborz, J., Novak, W. “Automotive Transmissions- Fundamentals, Selection, Design and Application”, Springer-ISBN 978-3-642-16214-5, 2011.
2. Kirpal singh ,"Automobile Engineering" “standard publishers, Distributors, Delhi, 1999.

Vehicle Dynamics

12630PC102	**Vehicle Dynamics**	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: Vehicular Systems

Course Objectives:

1. To enable students to understand the role of tire mechanics in vehicle dynamics
2. To enable students to understand and analyze the effect of road loads on performance of vehicles.
3. To enable students to understand significance, role of design of mechanism of chassis systems in vehicle dynamics and its effect on Stability of vehicle.
4. To analyze steady state and transient response of vehicle during cornering
5. To demonstrate how to apply fundamentals of vibrations to create the mathematical model to improve the performance of systems.

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

CO1:	Understand the forces and moments generated during Tire-Road interactions, which are responsible for cornering of vehicle
CO2:	Compute and analyze the effects of road load on performance and stability of vehicle.
CO3:	Outline the effects of design of various systems of vehicle on stability of vehicle.
CO4:	Demonstrate the different steering and vehicle suspension system, effect different parameter on performance of suspension system
CO5:	Compute steady state and transient response of vehicle during cornering & Create the mathematical model of vibration systems to optimize the performance parameters of vehicles

Mapping of course outcomes with program outcomes

	P01	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2		2								2
CO2	3	2	3	2	1							2
CO3	2	2	2									1
CO4	1	2	2							1		2
CO5	1	2	3	1		1				1		1

Course Contents:

Unit I Tyre Dynamics: **(07 Hours)**

Function and Requirement of Tyres, Material, Tyre adhesion, Types of tyres: Cross-ply and Radial-ply tyres, Tube and Tubeless tyres, Static and Dynamic forces acting on tyres, Cornering properties of tyres, Tractive and Braking Performance of tyres on different surfaces, Noise level of tyres.

Unit II Road Loads: (07 Hours)

Yawing Moment, Pitching Moment, rolling moment, Side force, Lift force Aerodynamics: Aerodynamic drag, drag components, drag coefficient, Rolling Resistance: Factors affecting to rolling resistance, Rolling resistance coefficient, Gradient Resistance: Gradeability, gradient coefficient, total road loads. Performance Characteristics: Maximum tractive force, Tractive torque, Surplus power, Surplus torque**.**

Unit III Vehicle Ride Characteristics: (07 Hours)

Excitation Sources: Road roughness, Driveline excitation, Engine and Transmission excitation, Vehicle ride models-Concept of Quarter car model, Half car model, Vehicle response properties- bounce and pitch motion, Suspension isolation, Suspension nonlinearity, active control, Wheel hop resonance.

Unit IV Steering and Suspension System: (07 Hours)

Steering geometry, Design of steering system, Ackermann mechanism, Davis mechanism, Wheel alignment Camber, castor, kingpin inclination, toe-in, toe –out and scrub radius, Four-wheel steering system, Forces and moments on steering system. Handling Characteristics: Over steer and under steer, Rigid axle and independent suspension system. Hotchkiss drive, torque-tube drive and radius rods, Shock absorber Types of suspension springs and their characteristics. Dynamic axle loads, Anti-squat, anti-pitch and anti-dive suspension geometry.

Unit V Vehicle Stability and Mechanical Vibrations: (07 Hours)

Steady state cornering, low speed turning, high speed turning tire cornering forces, cornering equations, under steer gradient, critical speed, characteristic speed, Yaw velocity gain, Side slip angle, lateral acceleration gain, Suspension effects on cornering- Roll moment distribution, camber change, effect of tractive forces on cornering, Roll Centre, Roll axis, Stability against body rolling, Vehicle stability while braking

Mechanical Vibrations: Mathematical model of Single Degrees of Freedom System, Multi Degree of Freedom System, Determination of natural frequency of system, damping characteristics, resonance, Transient Vibrations.

Textbooks:

1. Reza N Jazar “Vehicle Dynamics: Theory and Application”, 3rd Edition, Springer International Publishing AG, Switzerland, 2017

References:

1. Thomas D. Gillespie,(1992), “Fundamentals of Vehicle Dynamics (R114) Publisher: Society of Automotive Engineers Inc.,1992
2. J. Y. Wong (2008), “Theory of Ground Vehicles”, 4th Edition, John Wiley and Sons Inc., New York, 2008. Heins Heisler, “Advanced Vehicle Technology”

Automotive Materials

12630PC103	Automotive Materials	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-Requisites: Chemistry, Material Science.

Course Objectives:

1. To enable students to better understand material properties.
2. To enable students for selection of material.
3. To enable students for selection of appropriate testing and inspection methods for materials.
4. To enable students to application of materials for automotive components.

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

CO1	Understand the material properties for automotive components.
CO2	Identify the Metallic Materials for Automotive Components.
CO3	Identify the Non-Metallic Materials for Automotive Components.
CO4	Suggest Appropriate Modern Material for Automotive Components.
CO5	Select the Testing and Inspection Method for failure Mechanism of Automotive Components.
CO6	Understand the Application of Specific Materials for Automobile Parts & Components.

Mapping of course outcomes with program outcomes

PO → / CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2						1				1
CO2	2	1										
CO3	2	1										
CO4	2	1					1	1		1		
CO5				2	2					1		
CO6	2									1		

Course Contents:

Unit I Classification and Selection of Material for Automotive Components: **(07 Hours)**

Material categories, Classification of materials, Functional Aspect of Automotive Material, Factors Affecting selection of Materials for Automotive Parts & Components. Criteria for selecting materials for automotive components such as cylinder block, Cylinder head, piston, piston ring, Gudgeon pin, connecting rod, crank shaft,

crankcase cam, cam shaft, engine valve, gear wheel, clutch plate, axle, etc.

Unit II Metallic Materials for Automotive Components: (07 Hours)
Effect of material properties for Automotive Components, Strengthening mechanisms and their need in automotive Components, Ferrous and nonferrous metals, Classification of Steel for Automotive Use. Analysis, Advantages and Limitations of metallic materials for automotive applications, Strength, and Weight Consideration in Automotive Components.

Unit III Non-metallic Materials for Automotive Components: (07 Hours)
Polymers and Properties of polymers, Need, Properties, and applications of Thermoplastic, thermosets and Ceramics in Automotive Components, Merits, limitations, and Remedies of non-metallic materials in automotive Components.

Unit IV Modern Materials for Automotive Components: (07 Hours)
Composite Materials, Metal-Matrix composites, Ceramic-Matrix Composites, Fiber reinforced Polymers or Fiberglass, Advanced Composites, Carbon Fiber, Smart Materials, Shape Memory Alloys. Sensors and High Temperature Materials for Automotive Applications.

Unit V Failure Analysis of Automotive Component: (07 Hours)
Failure Mechanism and Testing of Automotive Materials. Analysis of failure and identification of causes for failure and suitable remedies for the same from material and process perspective.

References:

1. M. F. Ashby and H. Shercliff, D. Cubon, (2007) Materials Engineering Science, Processing and Design, Butterworth Publications
2. C. Brian, G. Patrick and J. Colin. (2007) Automotive Engineering: Light Weight, Functional and Novel Materials, Taylor & Francis .
3. M. P. Groover. (2005) Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.
4. W. D. Callister. (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.
5. S. Kalpakjian and S. R. Schmid. (2003) Manufacturing Engineering and Technology, Pearson Education.

Automotive Electronics

12630PE104A	Automotive Electronics	PE-I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Prerequisites: - Basics of Automobile Engineering, Basics of Electronics Engineering

Course Objectives: - To help students to gain essential and basic knowledge of automotive electronic systems with the working principle and necessary design requirement as per the testing standards, so as to equip them with knowledge required for the automotive electronic development.

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

CO1	Understand the basic automotive mechatronics components, sensors, actuators and its interaction with automotive parameters.
CO2	Understand the working of the engine management system and other electronic control units in the vehicle.
CO3	Understand the working of the various Autotronics Systems used in automobiles.
CO4	Identify the use of multiplex networking for automotive applications.
CO5	Understand the different warning systems & safety systems used in Automotive vehicles.
CO6	Identify the applications of automotive mechatronics in different sub-domains of automobiles & recent trends.

Mapping of course outcomes with program outcomes

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2								1			
CO2									1		2	
CO3					2							
CO4		2										
CO5	1		2									
CO6		2			2				2			

Course Contents:

Unit I Sensors and Actuators: (07 Hours)

Fundamentals of Automotive Mechatronics & Control System, Engine sensors and actuator: Manifold Absolute Pressure sensor, knock sensor, Coolant and Exhaust gas temperature sensor, Exhaust Oxygen level sensor, Throttle position sensor, accelerator pedal position sensor & crankshaft position sensor, Air mass flow sensor. Solenoids, stepper motors and relays, piezo actuators. Chassis: - Steering wheel angle sensor, Vibration and acceleration sensors, Pressure sensors, Speed and RPM sensors, torque sensors.

Unit II Electronic Engine Management system: (07 Hours)

Microprocessor and Microcomputer controlled devices in automobiles, Architecture of an ECU, Electronic engine control: Input, output devices, electronic fuel control system, engine control operating modes, electronic ignition systems, Engine cooling and warm up control, acceleration, detonation and idle speed control-integrated engine system.

Unit III Electric Management System and Dashboard Instrumentation: (07 Hours)
Cruise control, adaptive cruise control, Automatic Transmission, Electronic suspension system, electronic steering control, transmission control, instrument cluster ECU, types of indication in the cluster, Bus system, CAN and LIN communication, Horns, wiper system and its types, keyless entry system, on-board diagnostics, diagnostics, future automotive electronic systems, Chassis Systems: ABS, TC, ESP, TPMS, Active Suspension, Active Steering system.

Unit IV Automotive Tools, Diagnosis & Networking: (06 Hours)
Multiplex data bus, Basic principle of networking, classification of automotive multiplex bus, Controller Area Network, Local Interconnect Network, Flex Ray, Most, Automotive Ethernet, Connected Cars. Diagnosis: tools and equipment, Oscilloscope, onboard diagnosis system, Electromagnetic compatibility & tests for EMC.

Unit V Warning and Alarm Instruments: **(08 Hours)**
Brake actuation warning system, low tire pressure warning system, driver information system, trafficators, flash system, oil pressure warning system, engine overheat warning system, air pressure warning system, speed warning system, door lock indicators, gear neutral indicator, horn design, permanent magnet horn, air & music horns.
Modern Trends:
Automotive navigation & application of navigation system, adaptive front lighting system, Comfort systems: central locking, Use of Machine learning and data analytics for the automotive applications (ADAS, vehicle Autonomy, prognostics, health monitoring).

References:

1. Tom Denton, Automobile Electrical and Electronic systems (2013), Fourth Ed., Rouletedge, taylor & Francis Group
2. T.mellard, Automotive Electronics, Butterworth Heinemann Ltd, 1991
3. Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics (Bosch Professional Automotive Information), by Konrad Reif, Springer Fachmedien Wiesbaden, 2014.
4. Understanding Automotive Electronics, Wiliam B. Ribbens, 5th Edition, Newnes, Butterworth–Heinemann.

Text Books:

1. William B.Ribben, Understanding Automotive Electronics (2003), 6th ed., Elsevier Science.

Vehicle Maintenance and Diagnostics

12630PE104B	Vehicle Maintenance and Diagnostic	PE-I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Prerequisites: - Basic Automobile Engineering, I.C. Engines

Course Objectives: -

1. To provide the students with sufficient background to understand the importance of vehicle maintenance, its types and their diagnostics techniques.
2. To equip students with the knowledge of engine and sub-system maintenance.
3. Develop the students to have in-depth knowledge about on-board diagnostics, chassis system diagnostics and electrical system diagnostics.

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

CO1	Possess the knowledge of overall vehicle maintenance and its types, on and off-board diagnostics and engine and its sub-system maintenance
CO2	Demonstrate the application of oscilloscope and on-board diagnostics for automobiles
CO3	Provide an in-depth knowledge about the diagnostics of engine subsystems like battery charging and starting systems, lubrication systems air supply and exhaust systems.
CO4	Gain the knowledge of chassis system maintenance and various diagnostics techniques applied to brakes, steering and suspension systems.
CO5	Acquire and analyze the maintenance and diagnostics of electrical system including HVAC, cruise control diagnostics, airbags diagnostics, advanced fault diagnostics and remote diagnostics.

Mapping of course outcomes with program outcomes

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1	1						
CO2			1									
CO3		2		2	2							
CO4				2			2					
CO5			2			2						

Course Contents:

Unit I Introduction: (07 Hours)

Need for maintenance, types of maintenance: preventive and breakdown maintenance, requirements of maintenance, preparation of checklists. Inspection schedule, maintenance of records, log sheets and other forms, safety precautions in maintenance: General safety, tool safety - Diagnostic Techniques - diagnostic process - diagnostics on paper - mechanical diagnostic techniques - electrical diagnostic techniques - fault codes - on and off-board diagnostics - Data sources

Unit II Engine Maintenance: (07 Hours)

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, Anti Corrosion and antifreeze additives

Unit III Oscilloscope Diagnostics and On-Board Diagnostics: (07 Hours)

Basic equipment - Oscilloscopes - Scanners - Fault code readers - Engine Analyzers - Sensors - Actuators - Ignition System - Other components - A first perspective - Petrol / Gasoline on-board diagnostics monitors - a second perspective

Unit IV Engine Systems: (07 Hours)

Diagnostics of Engine operation - Fuel system - Ignition - Emission - Fuel Injection - Diesel injection - Engine management - Fault finding information - air supply and exhaust systems - cooling - lubrication - batteries - starting system - charging system.

Electrical System:

Electronic components and circuits diagnosis - multiplexing - lighting - diagnosing auxiliary system faults - in car entertainment security and communication - body electrical system faults - diagnosing instruments system faults - HVAC diagnostics - Cruise control diagnostics - Air bags and belt tensions diagnostics

Unit V Chassis System Maintenance and Diagnostics: (07 Hours)

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, vehicle body maintenance - Diagnostics of brakes - anti-lock brakes diagnostics - traction control diagnostics - steering diagnostics - suspension diagnostics

Text Book:

1. Automotive Technician Training, Tom Denton, Taylor and Francis, New York, 2015

Reference Books:

1. Automobile Electrical and Electronic Systems : Automotive Technology – Vehicle Maintenance and Repair,
2. Tom Denton, Fourth Edition, Elsevier, New York, 2013.
   Advanced Automotive Fault Diagnosis: Automotive Technology- Vehicle Maintenance and Repair

Automotive HVAC

12630PE104C	Automotive HVAC	PE-I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Prerequisites: - Basic Automobile Engineering, Fundamentals of Thermodynamics & Heat Transfer

Course Objectives: - To help students to gain essential and basic knowledge of automotive HVAC systems with the working principle and necessary design requirement as per the testing standards, so as to equip them with knowledge required for the automotive HVAC development.

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

CO1:	Understand HVAC system & the requirements of HVAC in automobile applications
CO2:	Understand the different controls used in HVAC system.
CO3:	Understand the refrigerant and air managements
CO4:	Able to obtain Mathematical Models for different HVAC components
CO5:	Diagnose the problems with HVAC systems, identification of proper maintenance strategy.

Mapping of course outcomes with program outcomes

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2		1			3		2				1	
CO3			2								2	
CO4				2					1			
CO5					2	1						

Course Contents:

Unit I Introduction: (07 Hours)

Basic terminology, design factors and concepts related to air conditioning system- General Layout of automotive AC system, detailed study of HVAC components like compressor, evaporator, condenser, TXV, orifice tube, Receiver-drier, heater core etc. Orifice tube-based system- Heating system Location of air conditioning components in vehicle.

Unit II AC Control Devices: (07 Hours)

ATC system block diagram- different types of Sensors and Actuators, - Control Logic Electrical wiring diagram of manual and automatic system - multiplexing between BCM and PCM- control of compressor clutch, blower motor etc.- diagnostics tools and features, Vacuum Control system, electronic temperature Control, vacuum operated devices ie vacuum reserve tank, vacuum restrictor, vacuum motor, check valve & check relays, HPLP cut out, ambient switch & superheat switch, sun load sensor, outside temp sensor and in car temp sensor. AC control devices: Aspirator, blower clutch control, heater control & time delay relay for heater control.

Unit III Refrigerants & Air Management Systems: (07 Hours)

Refrigerants used their properties & relation between Temperature and pressure relation, computability

with lubricant oil, handling of refrigerants - Tapping into the refrigerant container – Environmental and safety aspects. Air management system: Air routing for manual, semi and automatic system- cases and ducts- Air distribution, control head and doors- Defrost system, , and system installation.

Unit IV Modeling of Air-Conditioning Components: (07 Hours)

Modeling of Fixed and variable Displacement type compressor, evaporator modeling- heat transfer correlations for the fluids inside the evaporator, analysis of evaporator frosting- condenser modeling - improvement of refrigerant flow control method.

Unit V Diagnosis and Maintenance of HVAC system: (07 Hours)

Inspection of HVAC system: Visual and acoustic, Sight glass, sound etc. Refrigerant leak detection, troubleshooting & servicing of compressor, evaporator, condenser, heater core etc. Charging Service equipment tools & refrigerant charging, hoses & connectors. Fault diagnosis and remedial actions. Air routing system services, Temperature Test.

Reference Books:

1. Goings L. F. “Automotive Air-conditioning” , American Technical services 1974.
2. Paul wiser “Automotive Air-conditioning”, Reston publishing Co inc 1990.
3. Mcdonald K. L. “Automotive Air-conditioning” , Theodire Audel Series 1978

Text books:

1. Tom Birch, Automotive heating and air conditioning- Pearson education Inc. 2003
2. Boice H. Dwiggins jack erjavec, “Automotive Heating Air-conditioning” delmer Publisher 2001.
3. William H course and Donald L Anglin “Automotive Air-conditioning” Mc-Graw H Hill Inc 1990.

Vehicle Aerodynamics

12630PE105A	Vehicle Aerodynamics	PE-II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: Fluid Mechanics

Course Objectives:

1. To understand fundamental principles of vehicle aerodynamics, including key equations and concepts.
2. To analyze aerodynamic forces and moments affecting vehicle performance, including various types of drag forces and their impact on fuel consumption and vehicle motion.
3. To optimize vehicle body shapes using body shape optimization techniques, focusing on practical applications such as boat tailing, windshield angle adjustments, and the effects of various body configurations.
4. To evaluate the impact of aerodynamic influences on vehicle performance concerning directional stability, safety, and comfort, considering airflow, noise generation, and environmental factors.
5. To conduct experimental and computational analyses using wind tunnel techniques and numerical methods, including computational fluid dynamics (CFD), to assess and improve vehicle aerodynamic characteristics.

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

CO1:	**Apply** fundamental principles of fluid mechanics to explain the aerodynamic behaviour of vehicles.
CO2:	**Calculate** aerodynamic forces and moments acting on vehicles and interpret the significance of drag fractions in vehicle design.
CO3:	**Evaluate** and optimize various vehicle body shapes, demonstrating knowledge of design adjustments that reduce drag and enhance performance.
CO4:	**Assess** vehicle performance related to aerodynamic stability, safety, and comfort, considering the implications of airflow on vehicle dynamics and passenger experience.
CO5:	**Design** and perform experiments in wind tunnels and utilize CFD software to analyze aerodynamic phenomena, leading to practical applications in vehicle design and optimization.

Course Content:

Unit 1: Fundamentals of Vehicle Aerodynamics (07 Hours)

Introduction to vehicle aerodynamics and its significance, Conservation of mass, momentum and energy, Navier-Stokes Equation, Bernoulli's Equation, Boundary Layer Theory, Compressible and inviscid flows, Fluid flow around vehicles, Internal and external flow phenomena related to vehicles, Aerodynamic forces and moments affecting vehicles, Resistances to vehicle motion including rolling resistance, aerodynamic resistance, and gradient resistance, Influence on vehicle performance, fuel consumption, and fuel economy, Car as a bluff body, Types of drag forces including form drag, skin friction drag, and induced drag, Analysis of aerodynamic drag, Drag fractions of cars and their impact on performance, Strategies for body shape development to reduce drag and improve fuel efficiency.

Unit 2: Body Shape Optimization (07 Hours)

Body shape optimization techniques, Front and rear windshield angle adjustment, Boat tailing, hatchback, fastback, and square back designs, Dust flow patterns at the rear and their effect on vehicle performance, Effects of gap configurations, fasteners, side panels, and spoilers, Case studies on drag reduction and body shape optimization.

Unit 3: Directional Stability, Safety, Comfort and Aeroacoustics (07 Hours)

Flow fields around vehicles: attached, separated, and oscillating flows, Vehicle behavior in cornering and side-wind conditions, Stability index and passing maneuvers, Safety considerations: water and dirt accumulation, visibility impairment, Comfort aspects: ventilation, airflow, and odour removal in vehicles, Influence of Airflow on the Interior and Exterior Noise of Motor Vehicle, Aerodynamic Noise Generation, Main Noise Sources and Options for Their Reduction.

Unit 4: Aerodynamics of High-Performance and Commercial Vehicles (07 Hours)

Aerodynamic considerations for high-performance vehicles, Design and placement of front wings and rear wings, Effects of weight distribution on aerodynamics including oversteer, understeer, and center of gravity, Slipstreaming techniques and their aerodynamic benefits, Aerodynamic drag and fuel consumption in commercial vehicles (trucks, buses), Strategies for reducing aerodynamic drag in heavy-duty vehicles, Aerodynamic features of high-performance vehicles including spoilers, diffusers, and air dams.

Unit 5: Experimental and Numerical Vehicle Aerodynamics (07 Hours)

Wind tunnel fundamentals, Design and working principles of wind tunnels, Types of wind tunnels including open-circuit, closed-circuit, and specialized automotive wind tunnels, Measurement and testing techniques, Transducers for measuring aerodynamic forces and moments, Pressure measurements, airflow velocity measurements, and flow visualization techniques, Numerical Methods and CFD for Vehicle Aerodynamics

Text Books:

1. Hucho W.H., “Aerodynamics of Road vehicles”, Butterworths Co. Ltd., 1997.
2. Wolf-Heinrich Hucho, “Aerodynamics of Road vehicles: From Fluid Mechanics to vehicle Engineering, 1990
3. T. Yomi Obidi, “Theory and Applications of Aerodynamics for Ground Vehicles”. Published by SAE with ISBN 978-0-7680-2111-0.
4. Rose McCallen, Fred Browand, “The Aerodynamics of Heavy Vehicles:Trucks, Buses, and Trains, Volume 1, 2004.

Reference Books:

1. Pope A, “Wind Tunnel Testing”, John Wiley & Sons, 2nd Edn., New York, 1994.
2. Automotive Aerodynamics: Update SP-706, SAE, 1987.
3. Vehicle Aerodynamics, SP-1145, SAE, 1996.

Finite Element Methods

12630PE105B	Finite Element Methods	PE II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-Requisites: Engineering Mechanics, Strength of Materials, Fluid Mechanics, Heat transfer

Course Objectives:

1. To learn basic principles and procedure of finite element analysis.
2. To learn the theory and characteristics of finite elements that represent engineering problems.
3. To learn and apply finite element solutions to structural, thermal, fluid, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.
4. To learn accuracy and validation of the FEA results**.**

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

CO1	Understand the basics of Engineering problems, Mathematical modeling of FEA.
CO2	Solve the 1-D and 2-D Finite Element Analysis problems.
CO3	Understand various Dynamic Analysis Methods using Finite Element Method.
CO4	Understand Applications in Heat Transfer & Fluid Mechanics.
CO5	Analyze Accuracy of the FEA results.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I Introduction to Finite Element Formulation of Boundary Value Problem: (07 Hours)

Weighted residual methods, Principle of stationary total potential, Rayleigh Ritz method, Galerkin's method, Finite element method, Meshing- elements, nodes, element types, meshing methods and aspect ratio

Unit II One Dimensional Finite Element Analysis: (07 Hours)

General form of total potential for 1-D applications, Generic form of finite element equations, Linear bar element, Quadratic element, Nodal approximation, Development of shape functions, Element matrices and vectors, Example problems, Extension to plane truss, Development of element equations, Assembly, Element connectivity, Global equations, Solution methods, Beam element, Nodal approximation, Shape functions,

Element matrices and vectors, Assembly, Solution, Numerical.

Unit III Two-Dimensional Finite Element Analysis: (07 Hours)

Introduction, Approximation of geometry and field variable, 3 noded triangular elements, Four noded rectangular elements, Higher order elements, Generalized coordinates approach to nodal approximations, Difficulties, Natural coordinates and coordinate transformations, Triangular and quadrilateral elements, Iso-parametric elements, Structural mechanics applications in 2 dimensions, Elasticity equations, Stress strain relations, Plane problems of elasticity, Element equations, Assembly, Need for quadrature formula, Transformations to natural coordinates, Gaussian quadrature, Numerical on plane stress, plane strain and axisymmetric applications.

Unit IV Dynamic Analysis Using Finite Element Method: (07 Hours)

Introduction, Vibrational problems, Equations of motion based on weak form, Longitudinal vibration of bars, Transverse vibration of beams, Consistent mass matrices, Element equations, Solution of eigen value problems, Vector iteration methods, Normal modes, Transient vibrations, Modeling of damping, Mode superposition technique, and direct integration methods.

Unit V Applications in HT, FM and Validation & Accuracy of FEA Results. (07 Hours)

One dimensional heat transfer element, Application to one-dimensional heat transfer problems, Scalar variable problems in 2-Dimensions, Applications to heat transfer in 2-Dimension, Application to problems in fluid mechanics in 2-Dimension.

Accuracy of the FEA results:

Validation and accuracy of FEA results, Computational accuracy: strain energy norm, residuals, Reaction forces and moments; convergence test, Average and unaverage stress difference.

Correlation with actual testing: strain gauging-stress comparison; natural frequency comparison; Dynamic response comparison, temperature and pressure distribution comparison.

Text Books:

1. S. S. Rao, “The Finite Element Method in Engineering,” 4th Edition, Butterworth-Heinemann, Oxford, 2018

Reference Books:

1. R.D. Cook, D. S. Malku, Concepts and applications of Finite Element Analysis, John Wiley and Sons, New York, Second Edition, 1981.
2. J. N. Reddy, An introduction to Finite Element Analysis, Tata McGraw- Hill Pub. Co., 2005.
3. T. J. R. Huges, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Dover Publications, 2000.
4. Chandrupatala and Belegundu, Introduction to Finite Elements in Engineering. Prentice Hall India,2003
5. P. Seshu, Textbook of Finite Element Analysis, Prentice-Hall of India Pvt. Ltd., New Delhi,2012.
6. David V Hutton, Fundamentals of Finite Element Analysis, McGraw-Hill Int. Ed. 2012.

Automotive Safety and Lighting

12630PE105C	Automotive Safety and Lighting	PE-II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-SemExam: 60 Marks	Total: 100 Marks	

Pre-Requisites: Automotive Body and Chassis Systems, Vehicle Dynamics.

Course Objectives:

1. To introduce Active and Passive Safety systems of Automobiles.
2. To broaden the importance of safety in automobiles.
3. To understand the Crash Testing and Quasi-Static tests of vehicles.
4. To understand the Global testing regulations.
5. To gain the basic knowledge of lighting of automotive vehicles.

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

CO1	Understand the design consideration in Automotive for occupant and pedestrian safety.
CO2	Understand types, working principle and importance of Passive and Active safety systems.
CO3	Explain the procedure of Automotive Crash testing with various global standards.
CO4	Design the vehicle with the consideration of ergonomics and injury biomechanics.
CO5	Explain the National, International regulations and test requirements, procedures of Automotive Lighting.

Mapping of course outcomes with program outcomes:

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1		1	1	1				2
CO2	1									2		2
CO3	3	1		1				1		1		2
CO4	2	2	3	2		1	1	1	2	1		1
CO5										3		1

Course Contents:

Unit I Introduction to Automotive Safety: (07 Hours)

History of progress of Safety, Importance of Safety, Definition and Terminology of Automotive Safety- Active and Passive Safety, Preliminary design safety considerations in Body in White (BIW), External forces to BIW, Crashworthiness consideration for occupant and pedestrian, Optimization of vehicle structures for crash worthiness. Integrated Safety: Pre-crash Safety, Crash Safety, Post-Crash Safety.

Unit II Automotive Active Safety Systems: (07 Hours)

Active Safety Systems: Driver assistance systems in automobiles, Anti Lock Braking System, Electronic Stability Control, Traction Control System, Electronics Brake Force Distribution System, Technology progress in automotive lighting, Gas Discharges lamps, LED, adaptive front lighting system, Daylight running lamps. Tire pressure monitoring system.

Unit III Automotive Passive Safety Systems: (07 Hours)

Passive Safety Systems: Survival space requirements, Restraints systems used automobiles, Seatbelt: Types, Components, Working function, Seat Belt with pre-tensioner and load limiter, Airbag: Operating sequence, Components, Types, Material, Crumple Zone, Occupant safety with Seating system: Seat design objectives, seat configuration, Anti Submarine seats, Head restraint systems, Knee restraint system, Pedestrian protection, Child Restraint Systems.

Unit IV Crash Testing and Quasi-Static Vehicle Tests with Global Safety Standards: (07 Hours)

Physics of Car crash, Impact Barriers, Crash Test: Need, Objectives, Behaviour of specific body structures in crash testing Types of Crash: Frontal Impact, Rear Impact, Side and Pole Impact, Roll Over: Kinematics, Crash test regulatory and procedure. Design requirements of automobile for mitigation of injuries, Photographic analysis of impact tests

Quasi-Static Tests and Standards: Seat & Seat Belt Anchorage Point Test, Vehicle Roof Strength test, Vehicle Side Structure Test. Pedestrian Impact, Occupant Protection Regulations, Global Regulations: AIS, ECE, FMVSS, TRAIS, GB, KMVSS, ADR.Euro NCAP test requirements.

Unit V Automotive Ergonomics and Injury Biomechanics: (07 Hours)

Importance of Ergonomics in Automotive safety, Locations of controls, Size India, Anthropometry, Human impact tolerance, Vehicle Injury pattern Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria and relation with crash and modeling and simulation studies in dummy.

Automotive Lighting System and Testing Equipments:

Types of Lights, Lamps, Basics of standards and detectors, spectral measurements and Colorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio-Photometer, Reflecto-meter, Colorimeter, Integrating sphere, types, application, coordinate system.

Text Books:

1. Jullian Happian-Smith _An Introduction to Modern Vehicle Design‘ SAE, 2002.

References:

1. Watts, A. J., et al "Low speed Automobile Accidents" Lawyers and Judges 1996.
2. Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles, MEP, London, 1995.
3. Edward A., Lamps and Lighting, Hodder & Stoughton, London, 1993.
4. Matthw Huang, “Vehicle Crash Mechanics”.

PG Lab - I

12630PC106L	PG Lab-I	PCC	0-0-2	1 Credits
Exam Scheme				
Continuous Assessment: 25 Marks		PR/OR: 25 Marks	Total: 50 Marks	

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

CO1	Design and Analyze the Automotive Components with the use of Modern Tools
CO2	Conduct the test on IC engines to measure the performance parameters and to evaluate the energy balance sheet.
CO3	Conduct the emission tests on SI engine and CI engines with Automotive Standards
CO4	Understand the Automotive Chassis Systems and their components.

Mapping of course outcomes with program outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3			2	2		3	3
CO2	3	3	3		3				3			3
CO3	3	3	3	2	3	3	2	2		2		3
CO4	1	1								1		2

Experiments on the following set-ups:

Any four practicals from the list will be conducted as a part of Automotive Lab.

1. Performance measurement on Single Cylinder Diesel Engine – Variable Load Test.
2. Evaluation of Energy Balance Sheet of Single Cylinder Diesel Engine.
3. Performance Test on Multi-Cylinder Petrol Engine.
4. Measurement of Exhaust gas emissions of SI 2/3/4 vehicle- Pollution Under Control Test.
5. Measurement of Smoke Density of Diesel Engine.

12630SE107	SEMINAR	SE	0-0-2	1 Credit
Exam Scheme				
Continuous Assessment 40		End-Sem Evaluation (OR) 60		Total 100

Course Objectives:

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To learn the report writing and presentation

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

CO1	Identify the topic for seminar from the recent areas and technologies in thermal and fluids engineering or related areas.
CO2	Carry out a detailed comprehensive survey of the literature related to the topic selected. Use information available from various sources like research papers, patents, websites, discussion with experts on the topic etc.
CO3	Comprehend the information, organize it and write technical reports. Give presentations on the topic to the group of students.
CO4	Identify and report latest developments and unresolved issues in the selected topic/area.
CO5	Analyze the impact of the technologies on the environment. Identify green technologies related to select a topic.

Mapping of course outcomes with program outcomes

POs → COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			2		1		3	2		1		2
CO2			2		2		2		2			
CO3			1		1			2		2	1	
CO4					3	1	2		2	1		3
CO5					1	1				1		2

Course Contents:

The seminar shall consist of the preparation of the report by the candidate on the topic mutually decided by himself and the supervisor. The topic should be a problem in the field of Mechanical Engineering and should have sufficient research orientation. The recent development in the field of the chosen topic needs to be understood by the candidate. The report must be presented in front of the examiners committee and other faculty members and students of the department. The committee should be set by the PG coordinator and Head, Mechanical Engineering for evaluation of the seminar.

12630AU108	STRESS MANAGEMENT	AC	2-0-0	Audit Course
Exam Scheme				
Mid-Sem Test: 20 Marks		Continuous Assessment: 20 Marks	Total: 40 Marks	

Course Objectives

- Understand the physiological and psychological aspects of stress and its impact on overall well-being.
- Learn and practice specific yoga postures, breathing exercises, and relaxation techniques to alleviate stress.
- Explore the connection between mindfulness, meditation, and stress reduction, fostering mental clarity.
- Discover holistic practices that promote better sleep, nutrition, and overall lifestyle habits for stress management.
- Develop practical skills to manage stress in daily life, enhancing resilience and promoting emotional balance.

Course Outcomes

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

CO1: Recognize the signs and sources of stress, understanding its effects on mental and physical well-being.

CO2: Master a variety of yoga techniques, including postures, breathing, and meditation, to effectively manage stress

CO3: Acquire relaxation strategies that promote calmness, reduce anxiety, and enhance overall mental clarity.

CO4: Incorporate healthy habits inspired by yoga principles to foster better sleep, nutrition, and self-care routines.

CO5: Develop practical skills to navigate and cope with stress, enhancing emotional balance and promoting a more harmonious life.

CO-PO Mapping

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1		2		1						
CO2	2	1										
CO3	1	2		1						1		
CO4	2	2	1	1		2						
CO5												

Unit 1: (07 Hours)

Introduction to Yoga for Stress Management – 1, Introduction to Yoga for Stress Management - 2 Stress according to Western perspective, Stress Eastern Perspective, Developmental process: Western and Eastern Perspective Stress Hazards and Yoga.

UNIT II (07 Hours)

Meeting the challenges of Stress –1 Meeting the challenges of Stress - 2 Introduction to Stress Physiology Stress, Appetite and Dietary management- Modern and Yogic perspective Sleep and Stress: understanding the relationship for effective management of stress

UNIT III (07 Hours)

Stress Assessment methods- a valuable tool toward stress management Role of Yoga in prevention and management of stress related disorders – a summary of research evidence Concept of stress and its management- perspectives from Patanjali Yoga Sutra - Part 1 Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 2 Concept of stress and its management - perspectives from Patanjali Yoga Sutra - Part 3

UNIT IV (07 Hours)

Concept of stress and its management - perspectives from Bhagavad Gita - Part 1 Concept of stress and its management - perspectives from Bhagavad Gita - Part 2 Concept of stress and its management - perspectives from Bhagavad Gita - Part 3

UNIT V (07 Hours)

Asana practices – 1 Tadasana, Ardhakati Chakrasana, Ardha Chakrasana, Trikonasana, Vrikshasana Asana practices – 2 Vakrasana, Janu Sirshasana, Ushtrasana, Sashankasana, Asana practices – 3 Ardhamatseyndrasana, Paschimottanasana, Poorvottanasana, Gomukhasana Asana practices – 4 Makarasana, Bhujangasana, Salambha Shalabahasana, Dhanurasana Asana practices – 5 Setu Bandhasana, Sarvangasana, Matsyasana, Deep Relaxation Technique (DRT)

Textbooks/References Books:

1. H R Nagendra and R Nagarathna. Yoga for Promotion of Positive Health. Swami Vivekananda Yoga Prakashana. 2011.
2. Contrada, R., & Baum, A. (Eds.). The handbook of stress science: Biology, psychology, and health. Springer Publishing Company. 2010
3. Al'Absi, M. (Ed.). Stress and addiction: Biological and psychological mechanisms. Elsevier. 2011.
4. Van den Bergh, O. Principles, and practice of stress management. Guilford Publications. 2021.
5. Swami Muktibodhananda, Hatha Yoga Pradipika, Bihar School of Yoga, 1998
6. Swami Satyananda Saraswati, Four Chapters on Freedom, Bihar School of Yoga, 1975
7. Swami Tapasyananda, Srimad Bhagavad Gita, Sri Ramakrishna Math, 2012

NPTEL platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Yoga for Stress Management	Dr H RNagendra, Dr Mithila M V, Dr Rajesh Nair	Swami Vivekananda Yoga Anusandhana Samsthana	https://onlinecourses.swayam2.ac.in/aic23_ge10/preview#:~:text=In%20this%20course%20we%20intend,meeting%20the%20challenges%20of%20stress

SEMESTER-II

Alternative Fuels and Emissions

12630PC201	Alternative Fuels and Emissions	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-requisites: I.C. Engines.

Course Objectives:

1. To enable students to understand the need of alternative fuels in I.C. Engines.
2. To enable students to compare the properties of alternative fuels with conventional fuels.
3. To enable students to understand the necessity of emissions norms in automobiles.
4. To enable students to understand the standard emission testing procedures used in automobiles.

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

CO1	Understand types of fuels, its refining process and various properties.
CO2	Describe various types of alternative fuels, elaborate dual fuel engines working and learn about the modification.
CO3	Compare and analyze all the factors affecting the formation and reduction of emissions from engines.
CO4	Understand automotive noise limits and its control techniques.
CO5	Suggest, identify and design various emission control techniques and understand standard testing procedures of it.

Mapping of course outcomes with program outcomes

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

Course Contents: -

Unit I Fuels and its Properties: (07 Hours)

Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels, physical and chemical properties of fuels, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

Unit II Alternative Fuels: (06 Hours)
Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing. Biodiesels, Need of biodiesels, Properties of biodiesels V/s petrol diesel, Performance, and emission characteristics of biodiesels v/s Petro diesel operation.

Unit III Dual Fuel Engines: (06 Hours)
Need and advantages, the working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.

Unit IV Emissions from SI and CI Engines: (10 Hours)
Kinetics of NOx formation, NOx formation in SI Engines, NOx formation in CI Engines, factors affecting NOx formation in SI and CI engines, Carbon Monoxide Formation, Flame Quenching and Oxidation, Particulate Matter Formation, Types of Smokes, Effects of all emissions on ecology, Optimization of Engine Parameters for Improving the Combustion to reduce the emissions, NOx-HC Tradeoff, Bharat Stage Emission Norms. Measurement of CO, CO2, by NDIR. Hydrocarbon by FID – Chemiluminescent detector for NOx measurement, Smoke meters – Dilution tunnel technique for particulate measurement, Emission test cycles.
Exhaust Gas Recirculation, SCR, Urea Dosing System, Nox Adsorber, Catalytic converter, Diesel Oxidation Catalyst, Diesel Particulate Filter (DPF), lean burning, engine temperature control.

Unit V Noise Pollution: (06 Hours)
Noise pollution from automobiles, Sources of Noise, Engine Noise, Transmission Noise, vehicle structural Noise, aerodynamics noise, Exhaust Noise. Noise reduction in Automobiles, Encapsulation technique for noise reduction — Silencer Design, Noise emission regulatory norms.

Text / Reference books:-

1. John B Heywood, “Internal Combustion Engine Fundamentals”, (2011), McGraw Hill Education.
2. V. Ganesan, “Internal Combustion Engine”, (2012), 4th Edition, McGraw Hill Education.
3. James D Halderman, “Automotive Fuel and Emissions Control Systems”, (2015), Prentice Hall, 4th Edition.
4. H.N.Gupta “Fundamentals of IC engine”, Prentice Hall, 2nd edition.

Advanced Automotive Engine Technology

12630PC303	Advanced Automotive Engine Technology	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-Requisites: Applied Thermodynamics

Course Objectives:

1. To enable students to understand the constructional details and fuel supply system of I. C. Engines.
2. To enable students to understand the phenomenon of combustion of SI and CI engines.
3. To enable students to evaluate the performance parameters of engines as well as compare the performance maps.
4. To enable students to understand the different standard testing cycles used to test the engines.
5. To understand the modern technologies associated with automobile

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

CO1	Describe and compare different types, Constructional details, Cycles of operation and fuel supply system of modern I. C. Engines
CO2	Compare the Design, Performance and Fuel quality factors affecting to avoid detonation/ knocking in SI and CI engines
CO3	Evaluate the Performance parameters of I. C. Engines and analyze the Performance maps
CO4	Understand the standard testing cycles and procedures to meet the automotive norms
CO5	Understand the need of modern trends in I.C. Engines

Mapping of course outcomes with program outcomes

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1									2		2
CO2	2	2	1	2		2				1		2
CO3	2	2	3			1	1	1				1
CO4				1			2					1
CO5							2	2		1		1

Course Contents:

Unit I Fundamentals of I. C. Engines: (07 Hours)

Introduction – Historical Review, Engine Types – Design and operating Parameters, Working of Two Stroke and Four Stroke Spark Ignition and Compression Ignition engine, Air Standard Cycle, Fuel-Air cycle, Actual Cycle, Valve timing diagram for low-speed engine and High speed engine.

Unit II Fuel Supply Systems:(07 Hours)

Fuel Supply System of engine: Carburettor, Modern Carburetors, Petrol Injection Systems: Multi Point Fuel

Injection System (MPFI), Gasoline Direct Injection (GDI), Electronic Fuel injection System, Jetronic Fuel Injection System.
Diesel Injection System and components, Strategies of fuel injection, Types of nozzles of injector, Electro-hydraulic Injectors, Common Rail Direct Injection (CRDI), Hydraulically actuated Electronically Controlled Unit Injector (HEUI Injection system).
Fuel supply systems for S.I. and C.I engines to use gaseous fuels like LPG, CNG and Hydrogen

Unit III Combustion: (07 Hours)
Combustion of SI engine: Stages of combustion, factors affecting Flame front propagation, Flame structure and Speed, Abnormal combustion, Types of abnormal combustion, Knocking theories, Factors affecting to Knocking, Octane number measurement.
Combustion of CI engine: Stages of Combustion, Factors affecting ignition delay period, Spray characteristic, spray penetration, droplet distribution, Knocking in CI engine, Factors affecting to knocking, Cetane number measurement. Comparison of Knocking of SI and CI engine

Unit IV Combustion Chambers and Boosting Systems: (07 Hours)
Combustion chambers of SI engine, Combustion chambers of CI engines: Direct Injection and Indirect injection. Charge motion: Turbulence, turbulence generation methods, Swirl, Swirl generation methods, Squish. Supercharger and Turbocharger Engine, Turbo-Compounding.
Modern Trends in IC Engines: (07 Hours)
Lean Burning and Adiabatic concepts, Rotary Engines, Modification in I.C engines to suit Bio – fuels, HCCI and GDI concepts, BS-VI Emission Norms, Noise Pollution Norms. Hydrogen powered fuel cell Vehicles.

Unit V: Engine Testing and Performance of SI and CI engines: (07 Hours)
Performance parameters of engine, SI engine performance map, CI engine performance map, Variables affecting to SI and CI engine performance, Performance measurement tests, Morse Test, Willian's line method, Heat balance sheet., Types of dynamometers, Chassis dynamometer, Study of India Driving cycle (IDC).

Textbooks:

1. V.Ganesan, 'Internal combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2005.
2. John. B. Heywood,'Internal Combustion Engines'", Tata McGraw Hill Co., New York.
3. "Internal Combustion Engines By R K Rajput"

Reference Books:

1. W.H.Crouse and A.L.Anglin, 'Automotive Emission Control', McGraw Hill Book Co.
2. The I.C. Engine in theory and Practice Vol.I / Teylor / IT Prof.AndVol.II
3. Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.

Hybrid and Electric Vehicles

12630PC202	Hybrid and Electric Vehicles	PCC	3-1-0	4 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Course Objectives:

1. To provide the students with sufficient knowledge on series, parallel and full hybrid architectures of automobile vehicles.
2. To enable the students to understand the concept of electric drive trains, hybrid architectures and hybrid power plant specifications.
3. To help the students to understand the concept of sizing the drive system, energy storage and their alternatives, energy management and control system.
4. To help the students to analyze the various types of battery and Fuel cell technology.
5. To help the students to Characterize, inspect and maintain various Battery and Fuel cell performance.

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

CO 1	Compare the various architectures used in the hybrid vehicle and associated technologies.
CO 2	Describe the electric drive trains of hybrid and electric vehicles
CO 3	Understand the concept of sizing the drive system, energy storage and their alternatives, energy management and control system.
CO 4	Describe the various types of batteries and Fuel cell technology.
CO 5	Characterize, inspect and maintain various Battery and Fuel cell performance.

Mapping of course outcomes with program outcomes

PO → / CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1				1	1				
CO2	1	1	1					1				
CO3	2	2	1		1	1						
CO4	1	1	1		3							
CO5	2	1	2	1		3	1	1				

Unit I: Hybrid vehicle architectures **(07 Hours)**

Series hybrid vehicle architectures, range extender and full hybrid systems, parallel hybrid architectures, Plug-in hybrid architectures, commercially available electric and hybrid vehicles, degree of hybridization.

Unit II: Electric Drive trains **(07 Hours)**

Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis, Electric Propulsion unit, Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch, Reluctance Motor drives, drive system efficiency.

Unit III: Sizing the drive system **(07 Hours)**

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

Unit IV: Battery performance and selection **(07 Hours)**

Introduction, types of battery, Battery Performance Measurements, Factors Affecting Battery Performance, battery Standardization - Battery Design – Battery Management System - Battery Fault Detection, Maintenance and Test - Battery Installation - Selection of Battery for Automotive application,

Advance batteries: General Characteristics, Description of the Electrochemical Systems, Cell Design and Performance Characteristics of - Metal/Air Batteries - Zinc/Bromine Batteries - Sodium-Beta Batteries – Lithium / Iron Sulfide Batteries.

Unit V : Fuel cells **(07 Hours)**

Introduction and overview of fuel cells, types of fuel cells, technology, low and high temperature fuel Cells, Fuel cell reaction kinetics, Introduction to electrode kinetics, performance characteristics of fuel cells, efficiency of fuel cell, fuel cell stack, fuel cell power plant, fuel processor, fuel cell power section, power conditioner.

Text / Reference books: -

1. John Miller “Propulsion Systems for Hybrid Vehicles”, Institute of Electrical Engineers, UK, 2004
2. C.M. Jefferson & R.H. Barnard “ Hybrid Vehicle Propulsion”, WIT Press, 2002
3. Iqbal Husain “Electric and Hybrid Vehicles – Design Fundamentals”, CRC Press, 2010
4. Chris Mi, M A Masrur, D W Gao “Hybrid Electric Vehicles – Principles and applications”, with practical perspectives, Wiley, 2011
5. David Linden and Thomas B. Reddy “ HandBook of Batteries” Third Edition , McGraw Hill, NY, 2010
6. Robert A. Huggins “Advanced Batteries - Material Science Aspects”, Springer Publications, NY 2009

Computational Numerical Methods

12630PE203A	Computational Numerical Methods	PE III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Prerequisites: - Basic Engineering Mathematics

Course Objectives: -

1. To provide the students with sufficient exposure to advanced mathematical methods and tools that are relevant to engineering models.
2. Improving the computational skills of students by giving sufficient knowledge of numerical integration and differentiation techniques useful for solving problems arising in Mechanical Engineering.
3. Imparting the knowledge of real time applications of Autonomous systems, linear systems of ordinary differential equations and partial differential equations.

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

CO1	Students will be able to understand the Numerical integration and differentiation and solution of ODE.
CO2	Students will be able to analyze and develop the mathematical model of an engineering system using Numerical method for algebraic equation
CO3	Students will be able to develop the mathematical model using statistical and numerical techniques.
CO4	Students will be able to solve differential equations using numerical techniques.

Mapping of course outcomes with program outcomes

PO → / CO ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1	1	1									
CO3	1	1										
CO4	1			1								

Course Contents:

Unit I Numerical Integration and Differentiation: (07 Hours)
Motivation, Newton-cotes integration formula, Trapezoidal rule, Simpson's 1/3rd, 3/8th rule, numerical differentiation, and case Study.

Unit II Solution of Ordinary Differential Equation: (07 Hours)
Introduction, Picard's Method, Euler's Method, Modified Euler's Method, and Runge-kutta Method for solution of ordinary differential equations.

Unit III Solution of Algebraic and Transcendental Equation: (07 Hours)
Introduction to solution of Algebraic and Transcendental Equation: Bisection method, Method of false position,

Newton‘s method and Newton-Raphson method and case study.

Unit IV Solution of Linear Simultaneous Equation: (07 Hours)
Solution of Linear system of Equations, Matrix eigen value and eigen vector problem, Gauss elimination method, LU decomposition, and Gauss-Seidel iteration method case Study.

Unit V Mathematical Statistics: (07 Hours)
Principal of least square method, Linear regression, polynomial regression, exponential regression, Linear correlation, Introduction to linear correlation, coefficient of correlation.
Partial Differential Equation:
Introduction, Classification of second-order partial differential equations, Canonical form, Finite difference method for elliptic and parabolic equation

Text Books:

1. Numerical Methods for Engineers, Steven C. Chapra and Raymond P. Canale, Mc Graw Hill, 1st Edition, 1999.
2. Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar, R. K. Jain, New Age International publishers, 7th edition, New Delhi, 2019.
3. Elements of Partial differential equations, Ian N. Sneddon, Dover Publications, New York, 2006
4. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Pvt. Ltd., 5th Edition, New Delhi, 2015.

References:

1. Elements of Partial differential equations, Ian N. Sneddon, Dover Publications, New York, 2006.
2. Higher Engineering Mathematics, John Bird, fifth Edition, Elsevier, Linacre House, Jordan Hill, Oxford, 2006.
3. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999

Vehicle Crashworthiness

12630PE203B	Vehicle Crashworthiness	PE-III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Pre-Requisites: Automobile Engineering, Automotive Safety, Vehicle Dynamics

Course Objectives:

1. To provide sufficient knowledge of vehicle crashworthiness and its importance in the automotive industry.
2. To equip students with in-depth knowledge in human biomechanics behavior while loaded under crash conditions.
3. Assess the different test methodologies based on crash scenarios.
4. Analyze the effect of vehicle structures on Vulnerable Road Users (VRU).
5. To make the students familiar with vehicle ergonomics and vehicle safety systems.

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

CO1	Understand crashworthiness of the vehicle in the perspective of injury biomechanics and considerations while designing the vehicle.
CO2	Describe vehicle crash testing methods and international regulations used for it.
CO3	Classify different types of collision models of vehicle
CO4	Describe the various vehicle safety systems required for avoiding the accidents and mitigate the injuries.

Mapping of course outcomes with program outcomes:

POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1									2
CO2	1	1	1			1		1				2
CO3	2	1	1									1
CO4	2	1			2	1		1				1

Contents

Unit I: Fundamental of vehicle crashworthiness (07 Hours)

Vehicle crashworthiness, Crashworthiness Goals - Crashworthiness Requirements, Achieving Crashworthiness, Crashworthiness Tests, Motor Vehicle Safety - The Automobile Structure Materials and Characteristics of Vehicle Structures, types of impacts in car accidents NCAP rating.

Unit II: Crash Testing and Injury Mechanics (07 Hours)

Types of Collisions (Frontal, Rear, Side, Offset, Roll Over), Types of crash tests: Rigid barrier impact, direct central vehicle impact, pole test, roll over test, Regulatory requirements for crash testing - Instrumentation, high-speed photography, Image Analysis. Head Injury Mechanics - Neck Injury Mechanisms - Compression Injuries - Tension-Extension Injuries - Lateral Bending Injuries - Thoracic Injury Mechanisms - Low Speed Crush Injuries - High Speed Impact Injuries,

Unit III: Vehicle Collision Models (07 Hours)

Physics of Car collision, collision warning system, Impulsive models- central head on collision, oblique collision, collision against fixed obstacle, noncentral - head on collision, lateral collision, simplified approach. Second approximation models - head on collision against fixed - obstacle, Head-on collision between vehicles, and oblique collision between vehicles.

Unit IV: Vehicle Ergonomics and Pedestrian Safety (07 Hours)

Importance of Ergonomics in Automotive safety, concept of crumble zone, Locations of controls- Anthropometry- Human impact tolerance- Determination of Injury thresholds, Severity Index. Anatomical Scales: Abbreviated Injury Criterion (AIS).

Unit V: Vehicle Safety equipment (07 Hours)

Vehicle safety concept- Active safety and passive safety, seat belt and its function, collapsible steering column, air bags, electronic system for activating airbags, bumper design for safety types of rear-view mirrors and their assessment - Warning devices Door locks & retention systems Rear/front/side under run protection devices.

Text/Reference Books:

1. Vehicle Crashworthiness and Occupant Protection, Paul Du Bois, Clifford C. Chou and others, American Iron and Steel Institute.
2. Powloski. J - “Vehicle Body Engineering” - Business books limited, London – 1969
3. Johnson, W., and Mamalis, A.G., "Crashworthiness of Vehicles, MEP, London, 1995
4. Ronald. K. Jurgen - “Automotive Electronics Handbook” - Second edition- McGraw-Hill Inc., - 1999.
5. Jones, Andrew Zimmerman. "The Physics of a Car Collision." ThoughtCo, Aug. 27, 2020, thoughtco.com/what-is-the-physics-of-a-car-collision-2698920.
6. R M Macmillan, “Dynamics of vehicle collisions”, Edited by M. A Dorgham, Special kl publication SP5, Proceedings of the International Association for vehicle design.

12630OE203C	Industry 4.0	PE- III	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-Requisites: Advanced Manufacturing Techniques.

Course Objectives:

1. To understand the concept of Industry 4.0.
2. To familiarize the students about Framework and Technology Roadmap of Industry 4.0.
3. To understand the Advanced Robotics in the Era of Industry 4.0.

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

CO1	Describe Industry 4.0 and scope for Indian Industry.
CO2	Demonstrate conceptual framework and road map of Industry 4.0.
CO3	Describe Robotic technology and Augmented reality for Industry 4.0.
CO4	Demonstrate obstacle and framework conditions for Industry 4.0.

Mapping of course outcomes with program outcomes:

PO→ CO↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		3				1		3			2
CO2	2		2	1			1		1			2
CO3	2		3	3			1		1	2		2
CO4	2	3	3	2					2	2		2

Course Contents:

Unit I Introduction to Industry 4.0: (07 Hours)
Introduction, core idea of Industry 4.0,origin concept of industry 4.0,Industry 4.0 production system, current state of industry 4.0, Technologies, How is India preparing for Industry 4.0.

Unit II A Conceptual Framework for Industry 4.0: (07 Hours)
Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0.

Unit III Technology Roadmap for Industry 4.0 : (07 Hours)
Introduction, Proposed Framework for Technology Roadmap, Strategy Phase, Strategy Phase, New Product and Process Development Phase.

Unit IV Advances in Robotics in the Era of Industry 4.0: (07 Hours)
Introduction, Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic

Applications- Manufacturing, Maintenance and Assembly.

Unit V The Role of Augmented Reality in the Age of Industry 4.0: (07 Hours)
Introduction, AR Hardware and Software Technology, Industrial Applications of AR.

Obstacles and Framework Conditions for Industry 4.0
Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers, comprehensive broadband infra- structure, state support, legal framework, protection of corporate data, liability, handling personal data.

Reference Books:

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

IoT Technology

	IoT Technology in EV	OE-I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks		Total: 100 Marks

Pre-Requisites: Knowledge of Internet of things is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the fundamental concepts of IoT and its relevance to EV
CO2	Develop IoT-enabled systems for real-time battery monitoring
CO3	Apply IoT for real-time monitoring and optimization of powertrain systems
CO4	Identify security challenges and implement solutions for IoT in EVs
CO5	Implement control algorithms using IoT for ADAS

Mapping of course outcomes with program outcomes

PO→ / CO ↓	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3				2							
CO2	3		2		2							1
CO3	3	2		2	2							1
CO4	3	2	2	2	2	2						1
CO5	3	3	2	2	2	3						1

Course Contents:

Unit-I: Introduction to IoT in EVs: (7 Hours)
Definition, history, and evolution of Io, Key concepts and terminologies in IoT, Role and importance of IoT in electric vehicles, Applications of IoT in EV systems, Layers of IoT architecture (sensing, communication, processing, and application), Components of an IoT system (sensors, actuators, gateways, and cloud),
Overview of communication protocols (Wi-Fi, Bluetooth, Zigbee, LoRa, NB-IoT, etc.), Protocols specific to vehicular networks (V2V, V2I, V2X).

Unit-II: IoT for Battery Management and Monitoring: (7 Hours)
Architecture and components of IoT-enabled BMS, Data acquisition from battery cells and modules, Techniques for real-time monitoring of battery parameters (voltage, current, temperature),Using IoT sensors and gateways for data collection, Predictive Analytics, Remote Diagnostics.

Unit-III: IoT for Powertrain and Energy Management (7 Hours)
Role of IoT in powertrain control and optimization, Key parameters monitored by IoT (motor speed, torque, efficiency), IoT-based energy management systems (EMS), Real-time data acquisition and processing for energy optimization, Smart Charging, Predictive Maintenance

Unit-IV: IoT Security and Data Management in EVs (7 Hours)

Common security threats in IoT-enabled EVs, Vulnerabilities in IoT components and communication Encryption techniques for secure data transmission, Intrusion detection and prevention systems, Data acquisition, storage, and processing in IoT systems, Cloud and edge computing for IoT data management, Privacy and Compliance

Unit-V: IoT for Autonomous Driving and ADAS (7 Hours)

IoT in Autonomous Vehicles, Role of IoT in enabling autonomous driving, Key IoT components and their functions in autonomous vehicles, Perception Systems, IoT sensors for perception (LiDAR, radar, cameras, ultrasonic sensors), Data fusion and processing for environment understanding, Vehicle Communication, Vehicle-to-Everything (V2X) communication using IoT, Protocols and standards for V2X communication, Control Systems, IoT-based control systems for autonomous driving, Real-time data processing and decision making, Simulation and Testing, Platforms for simulating IoT-enabled autonomous driving systems, Testing and validation of IoT solutions in ADASTelematics and IoT, Cybersecurity Threats, AI-based Security Solutions.

Reference Books

1. **"Internet of Things: Principles and Paradigms"** by Rajkumar Buyya and Amir Vahid Dastjerdi
2. **"Building the Internet of Things"** by Maciej Kranz
3. **"IoT and Edge Computing for Architects"** by Perry Lea
4. **"Connected Vehicles: Intelligent Transportation Systems"** by Radovan Miucic
5. **"The Fourth Industrial Revolution"** by Klaus Schwab

12630OE204B	ENTREPRENEURSHIP	OE-I	3-0-0	3 Credits
Exam Scheme				
Mid-term Test 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To understand the role of entrepreneurs in driving innovation and economic growth.
2. Guide students through the process of developing a comprehensive business plan, including market research, financial projections, competitive analysis, and risk assessment.
3. Provide students with essential financial literacy skills, including budgeting, financial forecasting, and understanding different funding options such as bootstrapping, loans, venture capital, and angel investment.
4. Guide students through the process of developing, prototyping, and refining their products or services to meet customer needs and expectations.
5. To explore different sources of funding for technology startups.

Course Outcomes:

1. Students will be able to generate innovative business ideas by identifying market gaps, customer needs, and emerging trends.
2. Students will be capable of developing comprehensive business plans that encompass market research, financial projections, and strategic goals.
3. Students will gain skills in budgeting, financial forecasting, and managing financial resources for their entrepreneurial ventures.
4. Students will be able to identify and manage potential risks associated with entrepreneurship, including financial, operational, and market risks.

UNIT I (07 Hours)
Entrepreneurial Journey, Entrepreneurial Discovery, Ideation and Prototyping, Role of entrepreneurship in economic development, Types of business models for technology ventures

UNIT II (07 Hours)
Testing, Validation and Commercialization, Disruption as a Success Driver

UNIT III (07 Hours) Technological Innovation and Entrepreneurship – 1, Technological Innovation and Entrepreneurship – 2, Raising Financial Resources. International expansion and globalization

UNIT IV (07 Hours)
Education and Entrepreneurship, Beyond Founders and Founder-Families, India as a Start-up Nation, Marketing and sales strategies for startups

UNIT V (07 Hours)
National Entrepreneurial Culture, Entrepreneurial Thermodynamics, Entrepreneurship and Employment, Start-up Case Studies

Textbooks / References:

1. Zero to One: Notes on Startups, or How the Build the Future by Peter Thiel.
2. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries.
3. India as Global Start-up Hub: Mission with Passion by C B Rao.
4. Elon Musk: Tesla, SpaceX, and the Quest for a Fantastic Future by Ashlee Vance.
5. Steve Jobs by Walter Isaacson.
6. Innovation and Entrepreneurship: Practice and Principles by Peter F Drucker.
7. The Innovator's Solution: Creating and Sustaining Successful Growth by Clayton M Christensen.
8. "The Lean Startup" by Eric Ries

12630OE204C	RESEARCH METHODOLOGY	OE-I	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To synthesize information from literature reviews in engineering to identify and articulate research problems, while discerning gaps in existing knowledge.
2. To evaluate ethical considerations inherent in engineering research, demonstrating ethical behavior across all phases of the research process.
3. To justify the selection of appropriate research designs, data collection methods, and statistical analyses to meet specific engineering research objectives, ensuring methodological rigor.
4. To utilize computational tools and software in engineering to construct mathematical models, and to validate these models against empirical data for the analysis of engineering problems.
5. To communicate research findings effectively in engineering through the creation of well-structured reports, presentations, and visual aids, adhering to established professional standards and conventions.

Course Outcomes: Students will

CO1	Formulate research problems in engineering by synthesizing information from literature review and identifying gaps in existing knowledge.
CO2	Critically assess ethical considerations in research and demonstrate ethical behavior in all stages of the research process.
CO3	Select and justify appropriate research designs, data collection methods, and statistical analyses for specific research objectives.
CO4	Develop mathematical models using computational tools and software, and validate them against real- world data to analyze engineering problems.
CO5	Effectively communicate research findings through well-structured reports, presentations, and visual aids, adhering to professional standards and conventions.

UNIT 1: (07 Hours)

Research: meaning, objectives, motivation, types, Research process, Criteria of good research, Importance of literature review in defining a problem, Literature review: primary and secondary sources, Critical literature review, Identifying gap areas from literature and research database, Research problem: selection, necessity and formulation, Technique Involved in Defining a Problem, Hypothesis formation, Problems Encountered by Researchers in India,

UNIT 2: Research Ethics (07 Hours)

Ethical considerations in research, Plagiarism, Intellectual Property, Research Integrity, and misconduct, Ethical issues in data collection, experimentation, and analysis, Ethical considerations in publication and peer review, Case studies of ethical dilemmas in engineering research, Conflict of interest, Ethics in Emerging Technologies like AI

UNIT 3: Research Design, Experimentation, and Analysis And Data Analysis and Interpretation (07 Hours)

Experimental and non-experimental research designs, Sampling techniques, and sample size determination, Data collection methods: Surveys, interviews, and observation, Instrumentation and measurement techniques, Reliability and validity in research, Design of experiments and analysis of results, Data processing and cleaning, Statistical analysis: Descriptive and inferential statistics, Advanced data analysis techniques: Regression, ANOVA, and multivariate analysis, Interpretation of results. Reporting and presenting data

UNIT 4: Mathematical Modeling in Engineering Research, Use of Computer Technology and Software (07 Hours)

Introduction to mathematical modeling, Types of models: Deterministic and probabilistic, Model development and validation, Applications of mathematical modeling in mechanical or automotive engineering, Modeling with Ordinary Differential Equations (ODEs), Difference Equations in modeling, Partial Differential Equations (PDEs) in modeling, Case studies and examples, Introduction to computational tools: MATLAB, SPSS, R, Simulation and modeling software: ANSYS, SolidWorks, and other CAD tools, Data analysis software: Usage and applications, Big data and machine learning in engineering research

UNIT 5: Writing and Presenting Research (07 Hours)

Writing a thesis and project report: Structure and content, Writing progress reports and project updates, Structuring a research paper, Writing research proposals and grants, Writing for journals and conferences, Incorporating references and citations: APA, MLA, IEEE styles, Managing references with citation management software (e.g., EndNote, Zotero), Preparing and delivering oral presentations, Creating effective visual aids (charts, graphs, tables), Poster presentations: Design and delivery, The publication process and peer review, Communicating research to non-specialists and stakeholders

Textbooks/Reference:

- C. R. Kothari, Research Methodology, New Age Publishers.
- Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners
- Herman Tang, Engineering Research: Design, Methods, and Analysis
- Douglas C. Montgomery, Design and Analysis of Experiments
- C. Neal Stewart Jr., Research Ethics for Scientists: A Companion for Students

PG Lab II

12630PC205L	PG Lab-II	PCC	0-0-2	1 Credits
Exam Scheme				
Continuous Assessment: 60 Marks		PR/OR: 40 Marks		Total: 100 Marks

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

CO1	Design and Analyze the Automotive Components with the use of Modern Tools
CO2	Conduct the test on IC engines to measure the performance parameters and to evaluate the energy balance sheet.
CO3	Conduct the emission tests on SI engine and CI engines with Automotive Standards
CO4	Understand the Automotive Chassis Systems and their components.

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

Experiments on the following set-ups:

Any four practicals from the list will be conducted as a part of Automotive Lab.

1. CAD Modeling and Assembly of Automotive Components using CATIA/PRO-E/Solid Work/ Any suitable modeling software.
2. Mini project: On FEM analysis of any two Automotive Chassis System Components by using reputed commercial software for stress distribution, stress concentration and report writing on results of analysis. Using Ansys/Nastran/ Hypermesh/ LS-DYNA / any suitable analysis software.
3. Free Acceleration Test- Emission Measurement Test on Diesel Vehicle.
4. Study of Chassis Systems of Vehicles
5. Visit to Automotive Testing Track.

12630MP206	MINI PROJECT	ELC	0-0-2	1 Credits
Exam Scheme				
Continuous Assessment: 40 Marks		End-Sem Evaluation (PR/OR): 60 Marks		Total 100 Marks

Course Objectives:

1. To apply the basic engineering laws through a modeling/ model/setup
2. To understand the report writing and result analysis
3. To understand the problem formulation

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

CO1	Identify methods and materials to carry out experiments/develop code.
CO2	Reorganize the procedures with a concern for society, environment and ethics.
CO3	Analyze and discuss the results to draw valid conclusions.
CO4	Prepare a report as per recommended format and defend the work
CO5	Explore the possibility of publishing papers in peer reviewed journals/conference Proceedings.

Mapping of course outcomes with program outcomes

POs → COs ↓	P O1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12
CO1	2	2	1		2	2	1	1	2	2	1	2
CO2	1	1	2	2			2	2	1	2	1	2
CO3	2	2		3					2	2		1
CO4				2				2	2	3		1
CO5		1		2	2			2	2	3		1

Objectives:

To train students in identification, analysis, finding solutions and execution of live Mechanical Engineering and Managerial problems. It is also aimed to enhance the capabilities of the students.

Individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. Students can also choose live problems from Mechanical Engineering as their mini project. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Semester end examination will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, before the committee. Students individually will present their work before the committee.

12630AE207A	INDIAN KNOWLEDGE SYSTEM (IKS)	2-0-0	2 Credits
Exam Scheme			
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

CONCEPTS AND APPLICATIONS IN ENGINEERING

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

CO1: To familiarize learners with major sequential development in Indian science, engineering, and technology.
CO2: To review & strengthen the ancient discovery and research in physics, chemistry, math, metallurgy, astronomy, architecture, textile, transport, agriculture, and Ayurveda etc.
CO3: To help students to trace, identify and develop the ancient knowledge systems to make meaningful contributions to the development of science today.
CO4: To help to understand the apparently rational, verifiable, and universal solution from the ancient Indian knowledge system for the scientific, technological, and holistic development of physical, mental, and spiritual wellbeing.

Module 1: Indian Traditional Knowledge; Science and Practices (07 Hours)
Introduction to the Science and way of doing science and research in India, Ancient Science in Intra & Inter Culture Dialogue & coevolution. Traditional agricultural practices, Traditional water-harvesting practices, Traditional Livestock and veterinary Sciences Traditional Houses & villages, Traditional Forecasting, Traditional Ayurveda & plant-based medicine, Traditional writing Technology

Module 2: Ancient Indian Science (Physics, Chemistry, Maths) [Duration: (07 Hours)
Physics in India: Vaisheshika darshana Atomic theory & law of motion, theory of panchmahabhuta, Brihath Shathaka (divisions of the time, unit of distance), bhaskaracharya (theory of gravity, surya siddhanta & siddhanta shiromani), Lilavati (gurutvakashan Shakti). Chemistry in India Vatsyayana, Nagarjuna,Khanda, Al- Biruni, Vagbhaṭa –building of the ras-shala (laboratory), working arrangements of ras-shala, material and equipment, Yaśodhara Bhaṭṭa- process of distillation, apparatus, sarana samskara, saranataila Mathematics in India: Baudhayana‟s Sulba Sutras, Aryabhaṭa, Bhaskaracharya-I, Severus Sebokht, Syria, Brahmagupta, Bhaskaracharya-II, Jyeṣṭhadeva

Module 3: Ancient Indian Science (metallurgy, Astronomy, Architecture) (07 Hours)
Metallurgy in India: Survarṇa(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa(lead), Pittala(brass) Astronomy in India Vedang Jyotish, aryabhatta siddhanta, Mahabhaskriya, Laghubhaskariya, vateshwar siddhanta, Sisyadhivrddhida, Grahashyay,Goladhyaya, Kadanakutuhala (Aryabhaṭa, Varahamihira, Brahmagupta, Vaṭesvara, Bhaskara, Paramesvara, NilakaṇṭhaSomayaji, Jyeṣṭhadeva, ŚankaraVarman) Architecture in India: Nagara (northern style), Vesara (mixed style), and Dravida (southern style), Indian vernacular architecture, Temple style, cave architecture, rock cut architecture, kalinga architecture, chandels architecture, rajput architecture, jain architecture, sikh architecture, Maratha architecture Indo-Islamic architectural, Indo-Saracenic revival architecture, Greco Buddhist style.

Module 4: Ancient Indian Science (Textile, Agriculture, Transport) (07 Hours)

Textile Technology in India: Cotton (natural cellulose fiber), silk, wool (natural protein fibers), bast and leaf fibers, mridhudhautadhupitambaram (meaning a practice of fumigating the fabric with incense smoke before use as a part of the finishing process), sitadhautavasanayugala (bleached white–a finishing process); suchhastah, sutradhara (needle and thread – tools for stitching). dyeing, washing spinning and weaving technology, Agriculture in India: krishi suktas, Krishiparashara, Brihatsamhita, Types of crops, Manures, Types of land- devamatruka, nadimatruka, use of animals in warfare, animal husbandry, Animals for medicines. Ancient transport in India

Module 5: Ancient Indian Science (Ayurveda & Yoga) (07 Hours)

Ayurveda for Life, Health and Well-being: Introduction to Ayurveda: understanding Human body and Pancha maha bhuta, the communication between body & mind, health

References books:

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru.
2. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tattvabodha of shankaracharya, Central chinmaya mission trust, Bombay, 1995.
3. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.
4. SK Das, The education system of Ancient hindus, Gyan publication house, India
5. R P Kulkarni, Glimpse of Indian Engineering and Technology (Ancient & Medieval period, Munshiram Manoharlal Publishers Pvt. Ltd. 2018
6. AK Pathak, Science and Technology in India, Anshika prakashan pratapgarh, 2016
7. PB Sharma, S. Narain, Doctors Scientists and Engineers of Ancient India, Kalpaz Publications 2017
8. NVP, Unithiri, Indian Scientific Traditions (Professor K.N. Neelakantan Elayath Felicitation Volume), publication division university of Calicut, 2006
9. Anonyms, History of Science in India- Volume-I Part-I (Physics, Mathematics and Statistics), the national academy of science, India & the ramkrishna mission institute of culture, 2014

12612AE207B	INDIAN KNOWLEDGE SYSTEM (IKS)	2-0-0	2 Credits
Exam Scheme			
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

Humanities and Social Sciences

Course Objective

1. Introduce students to the foundational concepts, philosophies, and components of Indian knowledge systems, including ancient scriptures, philosophies, and traditional practices.
2. Introduce students to Vedic mathematical principles and computational techniques from ancient Indian texts, demonstrating their practical use in engineering calculations.
3. Explore the potential benefits of incorporating yogic and meditative practices into engineering to enhance focus, creativity, and overall well-being.
4. Study architectural concepts from Indian traditions and evaluate how they can inform modern urban planning and sustainable architecture.
5. Encourage students to draw inspiration from IKS to develop innovative engineering solutions that align with ancient wisdom while meeting contemporary needs.

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

CO1	Gain a comprehensive understanding of the philosophical, scientific, and technological aspects of Indian Knowledge Systems and their historical development.
CO2	Understand the philosophical underpinnings of IKS, including concepts like dharma, karma, and holistic thinking, and explore their relevance to engineering.
CO3	Understand Vedic mathematical principles and computational methods, and their potential relevance in solving modern engineering problems
CO4	Investigate the connections between yoga, meditation, and stress management, and their potential impact on mental well-being in engineering contexts.
CO5	Reflect on the ethical, cultural, and social dimensions of integrating IKS concepts into engineering practices and applications.

Mapping of course outcomes with program outcomes

POs→	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
COs↓												
CO1	1											
CO2	1											
CO3	1											
CO4						1						
CO5	2	1		1		2						

UNIT I (07 Hours)

Indian Knowledge System – An Introduction & Vedic Corpus

What is IKS? Why do we need IKS? Organization of IKS, Historicity of IKS, Some salient aspects of IKS, Introduction to Vedas, A synopsis of the four Vedas, Sub-classification of Vedas, Messages in Vedas, Introduction to Vedāṅgas, Prologue on Śikṣā and Vyākaraṇa, Basics of Nirukta and Chandas,

Introduction to Kalpa and Jyotiṣa, Vedic Life: A Distinctive Features.

UNIT II (06 Hours)

Number system & Mathematics

Number systems in India - Historical evidence, Salient aspects of Indian Mathematics, BhūtaSaṃkhyā system, Kaṭapayādi system, Measurements for time, distance, and weight, Piṅgala and the Binary system. Introduction to Indian Mathematics, Unique aspects of Indian Mathematics, Indian Mathematicians and their Contributions, Algebra, Geometry, Trigonometry, Binary mathematics, and combinatorial problems in Chandaḥ Śāstra, Magic squares in India.

UNIT III (07 Hours)

Engineering Technology: Metal & Other applications

Wootz Steel: The rise and fall of a great Indian technology, The Indian S & T heritage, Mining and ore extraction, Metals and metalworking technology, Iron and steel in India, lost wax casting of idols and artifacts, Apparatuses used for extraction of metallic components. Irrigation systems and practices in South India, literary sources for science and technology, Physical structures in India, irrigation and water management, dyes and painting technology, the art of making perfumes, Surgical techniques, shipbuilding, sixty-four art forms (64 Kalās) status of Indigenous S & T.

UNIT IV (06 Hours)

Town Planning and Architecture:

Perspective of Artha sastra on town planning, Vāstu-śāstra – The science of architecture, eight limbs of Vaastu, town planning, temples in India: Marvelous stone architecture for eternity, temple architecture in India, Iconography.

UNIT V (09 Hours)

Knowledge Framework and classifications:

Indian scheme of knowledge, The knowledge triangle, Prameya – A vaiśeṣikan approach to physical reality, Dravyas – the constituents of the physical reality, Attributes – the properties of substances and Action – the driver of conjunction and disjunction, Sāmānya, viśēṣa, samavāya, Pramāṇa – the means of valid knowledge, Saṃśaya – ambiguities in existing knowledge, Framework for establishing valid knowledge, Deductive or inductive logic framework, Potential fallacies in the reasoning process, Siddhānta: established tenets in a field of study.

Linguistics

Introduction to Linguistics, Aṣṭādhyāyī, Phonetics, word generation, computational aspects, Mnemonics, Recursive operations, Rule based operations, Sentence formation verbs and prefixes, role of Sanskrit in natural language processing.

Textbooks / References:

1. Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), ―Introduction to Indian Knowledge System: Concepts and Applications‖, PHI Learning Private Ltd. Delhi.

NPTEL platform:

NPTEL Course	Name of Instructor	Host Institute	Link
Indian Knowledge System (IKS): Concepts and Applications in Engineering	Prof. B. Mahadevan, Dr. Vinayak Rajat Bhat, Dr. R Venkata Raghavan	(IIMB), Chanakya University, Bangalore	https://onlinecourses.swayam2.ac.in/imb23_mg53/preview

Semester – III

Electric Vehicle Structural Design

PCC	Electric Vehicle Structure Design	3-0-0	3 Credits
Exam Scheme			
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks

Pre-Requisites: Knowledge of automobile vehicles, Types of two and four wheelers
Course Outcomes: At the end of the course, students will be able to:

CO1	Learn the structure of the vehicle.
CO2	Analyze the requirement and accordingly design for Electric Vehicles.
CO3	Understand the design basics for Electric Vehicles.
CO4	Learn modelling techniques for electric vehicle.
CO5	Analyze the stresses and strains in vehicle body using FEM

Mapping of course outcomes with program outcomes

PO→ CO ↓	1	2	3	4	5	6	7	8	9	10	11	12
CO1	2		2									1
CO2	3		2									1
CO3	2		3							1		1
CO4	3		3		3							1
CO5	3		3		3							1

Note: 1- Means least contribution, 2- Means medium contribution 3- Maximum contribution

Course Contents:

Unit I : **Introduction To CAD/CAM and Product Cycle: (8 Hrs)**
Representation of Line, Circle, & Other analytic curves, Algorithms & Programs. Drafting of machine elements with dimension and tolerances using 2-D drafting packages. Graphic standards GKS [Graphical Kernal System] IGES [Initial Graphic Exchange Specifications].

Unit II : CAD of Machine Elements: (7 Hrs)
Development of interactive design programs [with drafting] for machine elements, incorporating choice of materials and other parameters, Generation of several alternate designs and evaluation.

Unit III: Geometric Modelling: (8 Hrs)
Mathematical representation of Hermite cubic, Bezeir & B-spline curves. Introduction to difference type of surfaces and solids generated in surface and solid model respectively. Assembly modelling and interference checking.

Unit IV: Mechanical Design Analysis and Optimization: (8 Hrs)
Design analysis for mass properties, Stress, Thermal stress, using CAD/CAE packages, Optimum design of machine components using multivariable non-linear optimization techniques using iterative CAD/CAE software tools.

Unit V: Finite Element Analysis: (10 Hrs)
Basic concept of the finite element method, comparison of FEM with direct analytical solutions; Steps in finite element analysis of physical systems, Finite Element analysis of 1-D problems like spring, bar, truss and beam elements formulation by direct approach; development of elemental stiffness equations and their assembly, solution and its post processing.

Text Books

1. Ranky, P.G. Computer Integrated Manufacturing, Prentice Hall,1986.
2. Radhakrishanan,P. and Kothandaraman, C.P. Computer Graphics & Design, Dhanpat Rai & Sons, Delhi,1990.
3. Groover ,M.P. and Zimmers ,E.W CAD/CAM, Computer Aided Design and manufacturing, PrenticeHall of India 1986.

Reference Books:
1. Dimarogons, A.D. Computer Aided Machine Design, Prentice Hall, 1986.
2. Ibrahim Zeid, CAD/CAM Theory and Pratice, Mc Graw Hill, 1991.
3. Dimarogons, A.D. Computer Aided Machine Design, Prentice Hall, 1986.

Useful Links
1. https://nptel.ac.in/courses/112102101.
2. https://nptel.ac.in/courses/112102102.

Mechatronics and Robotics

OECI-01	Mechatronics and Robotics	OEC-II	3-0-0	3 Credits
Examination Schedule				
Mid-Sem Examination 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

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

CO1	Explain the role of mechatronics in manufacturing processes
CO2	Explain the need and significance of drives
CO3	Explain the need and significance of robotics in manufacturing
CO4	Develop an equations for motions
CO5	Explain the applications of robots

Unit 1: Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach. Review of fundamentals of electronics. Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

Unit 2: Drives: stepper motors, servo drives. Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. Description of PID controllers.

Unit 3: Introduction to robotics: brief history, types, classification and usage and the science and technology of robots. Kinematics of robot: direct and inverse kinematics problems and workspace, inverse kinematics solution for the general 6R manipulator, redundant and over-constrained manipulators.

Unit 4: Velocity and static analysis of manipulators: Linear and angular velocity, Jacobian of manipulators, singularity, static analysis. Dynamics of manipulators: formulation of equations of motion, recursive dynamics, and generation of symbolic equations of motion by a computer simulations of robots using software and commercially available packages.

Unit 5: Planning and control: Trajectory planning, position control, force control, hybrid control Industrial and medical robotics: application in manufacturing processes, e.g. casting, welding, painting, machining, heat treatment and nuclear power stations, etc; medical robots: image guided surgical robots, radiotherapy, cancer treatment, etc; Advanced topics in robotics: Modelling and control of flexible manipulators, wheeled mobile robots, bipeds, etc.

References:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.

2. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005

3. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning,2012.

4. S. K. Saha, ―Introduction to Robotics‖, Tata McGraw-Hill Publishing Company Ltd. (2008).

5 S. B. Niku, ―Introduction to Robotics–Analysis Systems, Applications‖, Pearson Education (2001).

6. . A. Ghosal, Robotics: ―Fundamental Concepts and Analysis‖, Oxford University Press (2008).

9. Pires, ―Industrial Robot Programming–Building Application for the Factories of the Future‖, Springer (2007).

12612OE301B	INTELLECTUAL PROPERTY RIGHTS	OE II	3-0-0	Credits: 3
Exam Scheme				
Mid-Sem Test: 20 Marks	Continuous Assessment: 20 Marks	End-Sem Exam: 60 Marks	Total: 100 Marks	

Course Prerequisites: Product Design, Design Thinking

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

CO1	State the fundamental terms i.e. trademark, copyright, patents, trade secret etc.
CO2	Interpret laws of trademark, copyright, patents, trade secret and its registration processes.
CO3	Understand the roles and responsibilities of various international organizations, agencies, and treaties.
CO4	Manage and safeguard the intellectual property and protect it against unauthorized use.

Mapping of Course Outcomes with Program Outcomes:

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1			1			1			1
CO2	1	1	1						1			1
CO3			1			1			1			1
CO4	2	1	1			1			1			1

UNIT I: Understanding and Overview of the IPR Regime (07 Hours)

Introduction, types of intellectual property- Copyright, Trademarks, Patents, Trade secrets. Need for Intellectual property rights, Rationale for protection of IPR. Impact of IPR on development, health, agriculture, and genetic resources. IPR in India- Genesis and Development. IPR abroad. International Organizations, agencies, and treaties.

UNIT II: Trademarks and Trade secret (07 Hours)

Rights of trademark-Kind of signs used as trademark types, Purpose and Function of a trademark, Trademark Protection, trademark registration, acquisition of trademark rights, protectable matters, selecting and evaluating trademark, trademark registration processes. Infringement of Trademark.

Geographical Indication of Goods: Geographical Indications (GI) laws, Indian Geographical Indications (GI) act, Types of Geographical Indications (GI), Need for protection, legal aspects.

Trade Secret: Trade Secret laws, determination of trade secret status, liabilities for misappropriation of trade secrets, protection for submission, trade secret litigation.

UNIT III: Copyrights (07 Hours)

Rights and Protection covered by copyrights- Laws of copyrights: Fundamental of copyright law, originality of material, rights of reproduction, rights to perform the work publicly, copyright ownership issues, obtaining copyright registration and process, international copyright law, Infringement of copyright under copyright act, the role, and liabilities of IPRs in India.

UNIT IV: Patents (07 Hours)

Kinds of inventions protected by patent, Patentable and Non patentable inventions, process and product patent, Legal requirements for patents-Granting of patent-Rights of a patent-exclusive right, Patent application process: Searching a patent- Drafting of a patent- Filing of a patent- Types of a patent application. Patent document: specifications and claims, Management of IP assets and IP portfolio, Commercial exploitation of IP- Assignment, licensing, infringement. Different laws of the international patent system: national, regional and international options.

Industrial Design protection.

UNIT V: New Development of Intellectual Property (07 Hours)

New development in trademark law, copyright law, patent law, trade secret law, Intellectual property audits. International overview on intellectual property, international trademark law, copyright law, international patent law and international trade secret law.

Textbooks:

1. Deborah, E. Bouchoux, "Intellectual Property Rights", Cengage learning.
2. Prabuddha Ganguli, "Intellectual Property right: Unleashing the knowledge economy", Tata McGraw Hill Publishing Company Ltd.

12630OE301C	Principles of Economics	OE-II	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. Introduce essential economic terms and concepts for analyzing real-world situations.
2. Understand market dynamics, supply and demand, and resource allocation.
3. Study national indicators, inflation, unemployment, and government policies' effects.
4. Learn to make informed choices using opportunity cost, utility, and cost analysis.
5. Explore global interdependencies, trade, exchange rates, and policy impacts.
6. To examine the relationship between technology, innovation, and economic growth.

Course Outcomes:

1. Grasp key economic principles, like supply and demand, opportunity cost, and marginal analysis, forming a foundation for economic understanding.
2. Gain insights into market structures, pricing mechanisms, and factors influencing consumer and producer behavior.
3. Understand the role of government interventions, regulations, and fiscal/monetary policies in shaping economic outcomes.
4. Learn how societies allocate scarce resources efficiently, exploring topics like production, distribution, and factors of production.
5. Develop analytical thinking by applying economic principles to real-world scenarios, making informed personal and business decisions.

UNIT I (07 Hours)
Principles of Economics, Thinking like an Economist; Interdependence and the gains from Trade, Economic models and analysis

UNIT II (07 Hours)
Market forces of supply and Elasticity, Application of elasticity; supply, demand, and government policies, Consumer behavior and utility maximization

UNIT III (07 Hours)
Consumer and producer surplus; cost of taxation and international trade, Externalities, and cost of production

UNIT IV (07 Hours)
Competitive market and monopoly market, Game theory and oligopoly, measures national income, measuring cost of living

UNIT V (07 Hours)
Production and growth; Saving, Investment and the financial system, the monetary system, Money growth and inflation

Textbooks / References:

1. N.Gregory Mankiw, Principles of Economics.
2. Microeconomics: Principles and Applications by Robert E. Hall and Marc Lieberman

12630MD302A	DESIGN OF MECHATRONIC SYSTEMS	Multidisciplinary Minor	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks		Total 100 Marks

Course Objectives:

1. To demonstrate proficiency in analyzing and modeling complex mechatronic systems, integrating knowledge of system dynamics, control theory, and signal processing to accurately represent system behavior.
2. To apply advanced control techniques, including Lyapunov theory, to design and implement control strategies for nonlinear systems, achieving stable and accurate trajectory tracking performance.
3. To utilize MATLAB for simulation and analysis of mechatronic systems, demonstrating the ability to validate theoretical models, analyze system responses, and optimize control algorithms.
4. To design and implement digital signal processing algorithms for mechatronic applications, including signal sampling, filtering, and interfacing with digital systems, ensuring effective signal conditioning and processing.
5. To evaluate and critique real-world mechatronic systems and research examples, such as 3D micro-printers and microfabrication platforms, demonstrating an understanding of the practical application of theoretical concepts and innovative engineering solutions.

Course Outcomes: Students will be able to;

CO1	Understand the theoretical foundations of mechatronics, including principles of system dynamics, control theory, and signal processing, with a focus on nonlinear control and digital systems.
CO2	Gain proficiency in mathematical modeling techniques for mechatronic systems, covering frictional dynamics, DC motors, manipulator dynamics, and their simulation using MATLAB.
CO3	Master advanced control methodologies, particularly Lyapunov theory, for designing robust and stable control systems capable of trajectory tracking in nonlinear dynamical systems
CO4	Develop practical skills in implementing digital signal processing techniques, including sampling,filtering, and interfacing with digital systems, essential for real-world mechatronic system implementation.
CO5	Explore cutting-edge research examples and case studies in mechatronics, such as the development of novel systems like 3D micro-printers and microfabrication platforms, to understand the application of theoretical concepts in innovative engineering solutions.

UNIT 1: **Mechatronics Essentials (07 Hours)**

Introduction: Elements of mechatronics system: Sensor, actuator, plant, and controller. Applications of mechatronics systems. Systems like CDROM, scanner

UNIT 2: Integrated Mechatronics: Design, Sensors, and Microprocessors (07 Hours) Integrated mechanical-electronics design philosophy. Smart sensor concept, utility of compliant mechanisms in mechatronics, Microprocessor building blocks, combinational and sequential logic elements, memory, timing and instruction execution fundamentals with example of primitive microprocessor.

UNIT 3: Microcontroller for Mechatronics (07 Hours)
Microcontrollers for mechatronics: Philosophy of programming interfaces, setting sampling time, and getting started with TIVA programming, Microcontroller programming philosophy emphasis on TIVA, programming different interfaces PWM, QEI etc. Mathematical modeling of mechatronic systems,

UNIT 4: Advanced Mechatronics: Dynamics, Control, and Simulation (07 Hours)
Modeling friction, DC motor, Lagrange formulation for system dynamics., Dynamics of 2R manipulator, Simulation using Matlab, Selection of sensors and actuators. Concept of feedback and closed loop control, mathematical representations of systems and control design in linear domain

UNIT 5: **Nonlinear Control and Digital Signal Processing** (07 Hours)
Basics of Lyapunov theory for nonlinear control, notions of stability, Lyapunov theorems and their application, Trajectory tracking control development based on Lyapunov theory, Basics of sampling of a signal, and signal processing, Digital systems and filters for practical mechatronic system implementation. Research example/ case studies of development of novel mechatronics system: 3D micro-printer, Hele Shaw system for microfabrication.

Textbooks/Reference:

- Devdas Shetty, Richard A. Kolk, “Mechatronics System Design,” PWS Publishing company
- Boukas K, Al-Sunni, Fouad M “Mechatronic,Systems Analysis, Design and Implementation,” Springer,
- Sabri Cetinkunt, “Mechatronics with Experiments,” 2nd Edition, Wiley
- Janschek, Klaus, “Mechatronic Systems Design,” Springer

12630 MD302B	ETHICAL HACKING	Multidisciplinary Minor	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Pre-Requisites: Computer Proficiency, Computer Networking

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

CO1	Gain a comprehensive understanding of ethical hacking concepts, methodologies, and its role in enhancing cybersecurity.
CO2	Acquire a solid grasp of cybersecurity principles, types of threats, and the importance of proactive defence strategies.
CO3	Develop proficiency in various hacking techniques, including reconnaissance, scanning, exploitation, and post-exploitation activities.
CO4	Perform effective vulnerability assessments on systems and networks, identifying potential security weaknesses and exposures.
CO5	Demonstrate the ability to conduct penetration tests, simulating real-world attacks to evaluate the strength of security measures

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes

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

UNIT I (07 Hours)

Introduction to ethical hacking. Fundamentals of computer networking. TCP/IP protocol stack. IP addressing and routing. TCP and UDP. IP subnets. Routing protocols. IP version 6.

UNIT II (07 Hours)

Installation of attacker and victim system. Information gathering using advanced google search, archive.org, net craft, dnsenum, NMAP tool, dig, etc.

UNIT III (07 Hours)

Vulnerability scanning using NMAP and Nessus. Creating a secure hacking environment. System Hacking: password cracking, privilege escalation, application execution. Malware and Virus. ARP spoofing and MAC attack.

UNIT IV (07 Hours)

Introduction to cryptography, private-key encryption, public-key encryption. Cryptographic hash functions, digital signature and certificate, applications. Steganography, biometric authentication, network-based attacks, DNS, and Email security.

UNIT V (07 Hours)

Packet sniffing using Wireshark and Burp suite, password attack using burp suite. Social engineering attacks and Denial of service attacks. Elements of hardware security: side-channel attacks, physical inclinable functions, hardware trojans. Different types of attacks using Metasploit framework: password cracking, privilege escalation, remote code execution, etc. Attack on web servers: password attack, SQL injection, cross site scripting.

Textbooks / References:

1. Data and Computer Communications -- W. Stallings.
2. Data Communication and Networking -- B. A. Forouzan
3. TCP/IP Protocol Suite -- B. A. Forouzan
4. UNIX Network Programming -- W. R. Stallings
5. Introduction to Computer Networks and Cybersecurity -- C-H. Wu and J. D. Irwin Cryptography and Network Security: Principles and Practice -- W. Stallin

12630 MD302C	Sustainable Power Generation Systems	Multidisciplinary Minor	3-0-0	3 Credits
Exam Scheme				
Mid-Sem Test 20 Marks	Continuous Assessment 20 Marks	End-Sem Exam 60 Marks	Total 100 Marks	

Course Objectives:

1. The course objective is to provide students a thorough understanding of different renewable energy sources. In particular, this course will cover the design and analysis of power plants that use renewable energy sources.
2. The course will employ practical examples, schematics, and block diagrams to illustrate concepts as needed. Additionally, numerical problems along with their solutions will be thoroughly addressed throughout the course.
3. This course targets undergraduate and postgraduate students specializing in Energy Engineering and Technology.
4. Moreover, the course will prove highly beneficial for students and researchers across diverse academic disciplines seeking to develop novel energy conversion devices and processes.

Course Outcomes:

1. Explain the principles of sustainability in the context of power generation and understand its significance in the global energy transition.
2. Identify and describe various renewable energy sources, including solar, wind, hydro, geothermal, and biomass, and explain their potential for power generation.
3. Examine and contrast pros and cons of various sustainable power generation technologies,accounting for factors like efficiency, scalability, reliability, and intermittency.
4. Assess environmental, social, and economic impacts of conventional and sustainable power generation methods, analyzing their roles in climate change mitigation and pollution reduction.

UNIT I

Introduction to power generation: (07 Hours)

Global and Indian Context: An Examination of Current Power Generation Technologies and Renewable Energy Concepts Introduction to Renewable Energy-Based Power Plants Solar Thermal Power Generation: Exploring the Basics of Solar Thermal Energy Conversion, Design, and Analysis of Solar Thermal Power Plants (including flat plate and concentrator technologies), Overview of Organic Rankine Cycle (ORC), Rankine Cycle (RC), and Stirling Engine Applications.

UNIT II

Solar Photovoltaic Power Generation: (07 Hours)

Solar Photovoltaic (PV) Energy Conversion: Understanding PV Fundamentals, PV Power Plant Design, Performance Analysis of Standalone and Grid-Connected PV Systems. Wind Power Generation: Introduction to Wind Turbines, Component Classification and Analysis, Design and Theory of Wind Turbines (Horizontal and Vertical Axis), and Wind Farm Analysis.

UNIT III

Hydro Power Generation: **(07 Hours)**

Hydropower Plants: Introduction to Hydro Power Plants, Micro, Mini, and Small Hydro Plants, Hydraulic Turbines, Selection and Design Criteria for Pumps and Turbines, Brief Theory, Design, and Analysis of Hydro Power Plants. Biomass Power Generation: Fundamentals of Bioenergy Production Technologies, Design and Analysis of Biochemical and Thermochemical Reactors for Clean Power Generation and Value-Added Products, Introduction

to Integrated Gasification Combined Cycle (IGCC).

UNIT IV

Hydrogen energy and fuel cells (07 Hours)

Hydrogen Generation: Importance and Various Generation Routes, Basic Principles and Design of Fuel Cells, Applications, Prospects, and Introduction to Integrated Gasification Fuel Cell (IGFC). Geothermal Energy: Fundamentals, Classification, Theory, Design, and Analysis of Geothermal Power Plants.

UNIT V

Ocean Thermal Energy (07 Hours)

Ocean thermal power plant principles, categorization, theory, design, and analysis Tidal and Wave Energy, Understanding the Fundamentals, Classification, Theory, Design, and Analysis of Wave and Tidal Power Plants. **Energy Storage,** Energy Storage Technologies: Overview of Thermal, Mechanical, and Electrochemical Energy Storage Systems; Design and Analysis of Various Storage Technologies. Week 12: Module-12: Energy Economics Cost Analysis, Financial Metrics (Interest, Accounting Rate of Return, Payback, Discounted Cash Flow, Net Present Value, Internal Rate of Return), Inflation, and Life Cycle Analysis for Energy Systems.

Textbooks / References:

1. J. Twidell, T. Weir, Renewable Energy Resources, Taylor and Francis, 4th Edition, 2021.
2. G. Boyle (Editor), Renewable Energy: Power for a Sustainable Future, Oxford University press, 3rd Edition, 2012.
3. G. N. Tiwari, Solar Energy, Fundamentals, Design, Modeling and Applications, Narosa, 2002.
4. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley, 4th Edition, 2013.
5. R. Gasch, J. Twele, Wind Power Plants: Fundamentals, Design, Construction and Operation, Springer, 2nd Edition, 2012.
6. P. Breeze, Hydropower, Elsevier, 1st Edition, 2018.
7. S. C. Bhattacharyya, Energy Economics Concepts, Issues, Markets and Governance, springer, 2nd Edition, 2019.
8. S.p Sukhatme and J.K. Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata Mc-Graw Hill Education Private Limited, 3rd Edition, 2010.

12630PR304	PROJECT - I	PCC		10 Credits
Exam Scheme				
Continuous Assessment: 50 Marks		End-Sem Evaluation (OR): 50 Marks		Total: 100

Course Objectives:

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To write problem statement and Objectives

Course Contents:

Project-I is an integral part of the final project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation that may include mathematical model/SRS/UML/ERD/block diagram/ PERT chart, and layout and design of the proposed system/work. As a part of the progress report of project-I work; the candidate shall deliver a presentation on progress of the work on the selected dissertation topic.

The student shall submit the duly certified progress report of project -I in standard format for satisfactory completion of the work duly signed by the concerned guide and head of the department/institute.

12630PR401	PROJECT-II	PCC		20 Credits
Exam Scheme				
Continuous Assessment: 100		End-Sem Evaluation (OR): 100		Total: 200

Course Objectives:

1. To understand the open literature
2. To familiarize the students about collection of technical literature, reading and understanding
3. To write problem statement and Objectives
4. To Analyze the problem and find probable solution
5. To write the project report

Course Contents:

In Project - II, the student shall complete the remaining part of the project which will consist of the simulation/ analysis/ synthesis/ implementation / fabrication of the proposed project work, workstation, conducting experiments and taking results, analysis and validation of results and drawing conclusions.

It is mandatory to publish the paper on the state of the art on the chosen topic in an international conference/ journal.

The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work duly signed by the concerned guide and head of the department/institute.