Marathwada Shikshan Prasarak Mandal's
DEOGIRI INSTITUTE OF ENGINEERING AND MANAGEMENT STUDIES
(An Autonomous Institute)
Affiliated to Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad | B.Tech. | M.Tech.
Affiliated to Dr. Babasaheb Ambedkar Marathwada University, CSN | MBA
Approved by AICTE/UGC-Govt. of India & DTE-Govt. of Maharashtra
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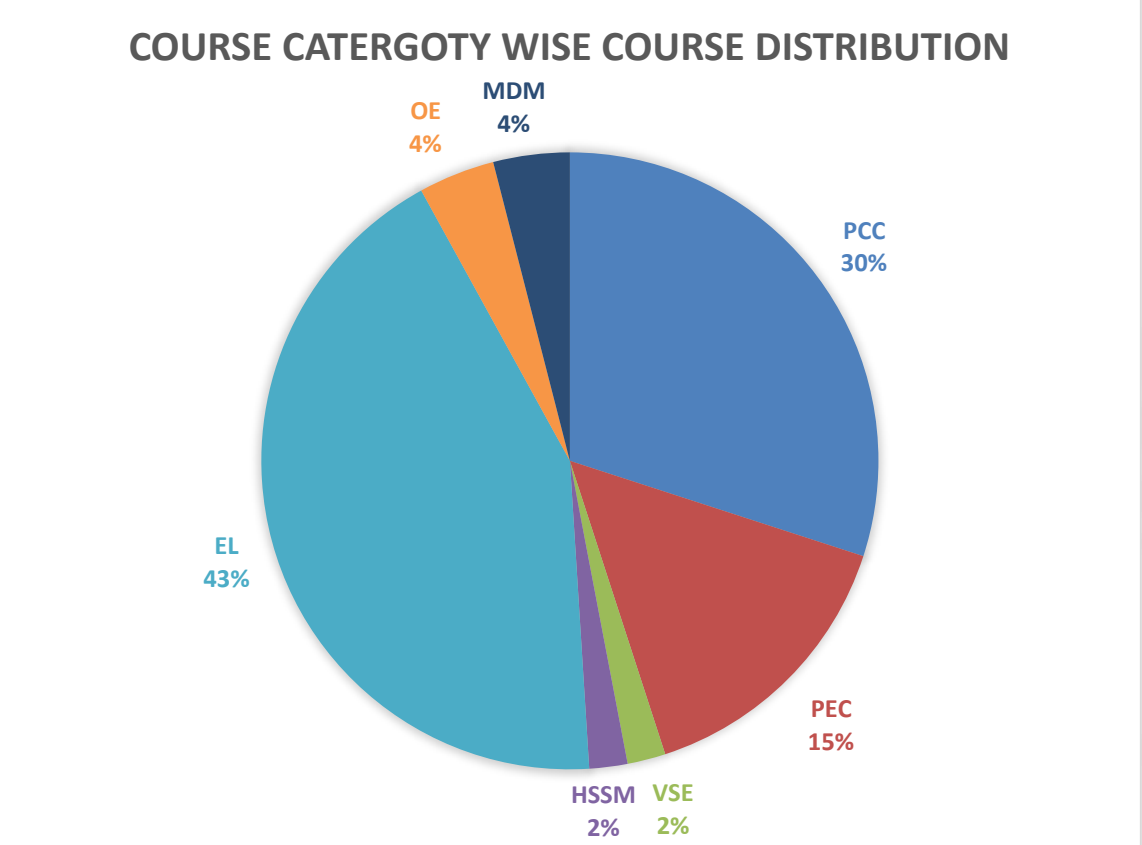
Department of Mechanical Engineering

M.TECH (AUTOMOTIVE TECHNOLOGY) PROGRAM STRUCTURE (2025-27)

Course Category			I	II	III	IV	Total Credits
Program Courses	Program Core Course (PCC)	-	12	04	04		24
		MOOC		04			
	Program Elective Course (PEC)		06	06			12
Vocational and Skill Education Courses (VSE)	Seminar		01				02
	PG Lab		01				
Humanities Social Science and Management (HSSM)	Indian Knowledge System (IKS)			02			02
Experiential Learning Courses (EL)	Research Methodology			03			34
	Mini Project			01			
	Project				10	20	
Open Elective Courses (OE)	Open Elective (OE)				03		03
Multi-Disciplinary Minor Courses (MDM)	Multi-Disciplinary Minor (MDM)				03		03
Liberal Learning Courses (LLC)	Co-Curricular Courses (CC)					AU	Audit
Total Credits			**20**	**20**	**20**	**20**	**80**

M.Tech in Automotive Technology		
Course Category	**Credits**	**% Credits**
Program Core Courses **(PCC)**	24	30
Program Elective Courses **(PEC)**	12	15
Vocational & Skill Enhancement **(VSE)**	2	2
Humanity, Social Science & Management (AEC, EM, IKS, VEC) HSSM	2	2
Experiential Learning **(EL)**	34	43
Open Electives **(OE)**	3	4
Multi-Disciplinary Minor (MDM)	3	4
Total Credits	**80**	



SEMESTER I												
Category	Course Code	Name of the Course	Teaching Scheme				Evaluation Scheme					Credits
			L	T	PR	Total	CA-I	CA-II	MSE	ESE	Total	
PCC	PA251001	Automotive Systems	4			4	10	10	20	60	100	4
PCC	PA251002	Vehicle Dynamics	4			4	10	10	20	60	100	4
PCC	PA251003	Automotive Materials	4			4	10	10	20	60	100	4
PEC	PA2511--	PEC I	3			3	10	10	20	60	100	3
PEC	PA2511--	PEC II	3			3	10	10	20	60	100	3
VSE	PA251401	Seminar			2	2	15	15		20	50	1
VSE	PA251402	PG Lab			2	2	15	15		20	50	1
Total			**18**		**4**	**22**					**600**	**20**

SEMESTER II												
Category	Course Code	Name of the Course	Teaching Scheme				Evaluation Scheme					Credits
			L	T	PR	Total	CA-I	CA-II	MSE	ESE	Total	
PCC	PA252004	Advanced Automotive Engine Technology	4			4	10	10	20	60	100	4
PCC	PA252005	MOOC/SWAYAM	4			4	10	10	20	60	100	4
PEC	PA2521--	PEC III	3			3	10	10	20	60	100	3
PEC	PA2521--	PEC IV	3			3	10	10	20	60	100	3
EL	PG252601	Research Methodology	3			3	10	10	20	60	100	3
IKS	PG252501	Interdisciplinary Perspective on Indian Science and Technology	2			2	10	10	20	60	100	2
EL	PA252602	Mini Project			2	2	15	15		20	50	1
Total			**19**		**2**	**21**					**650**	**20**

SEMESTER III												
Category	Course Code	Name of the Course	Teaching Scheme				Evaluation Scheme					Credits
			L	T	PR	Total	CA-I	CA-II	MSE	ESE	Total	
PCC	PA253006	Alternative Fuels and Emissions	4			4	10	10	20	60	100	4
OE	PA25335-	Open Elective	3			3	10	10	20	60	100	3
MDM	PA25320-	Multi-Disciplinary Minor	3			3	10	10	20	60	100	3
EL	PA253603	Project I			10	10	25	25		50	100	10
Total			**10**		**10**	**20**					**400**	**20**

SEMESTER IV												
Category	Course Code	Name of the Course	Teaching Scheme				Evaluation Scheme					Credits
			L	T	PR	Total	CA-I	CA-II	MSE	ESE	Total	
EL	PA254604	Project II			20	20	50	50		100	200	20
Total					**20**	**22**					**200**	**20**
CC	*PG254701*	*Communication Skills and Technical Writing*	*2*			*2*	*25*	*25*			*50*	*AU*

Program Elective Courses (PEC)

Semester	Course Category	No. of Credits		Course A	Course B	Course C
SEM-I	Program Elective I	3	**Course Code**	PA251101	PA251102	PA251103
			Course	Automotive Electronics	Vehicle Maintenance and Diagnostics	Automotive HVAC
	Program Elective II	3	**Course Code**	PA251104	PA251105	PA251106
			Course	Vehicle Aerodynamics	Finite Element Method	Automotive Safety and Crashworthiness
SEM-II	Program Elective III	3	**Course Code**	PA252107	PA252108	PA252109
			Course	Electric and Hybrid Vehicles	CAD-CAE	Automotive System Design
	Program Elective IV	3	**Course Code**	PA252110	PA252111	PA252112
			Course	Automated Guided Vehicles	Computational Fluid Dynamics	Automotive Testing and Certification

Open Electives (OE)

Semester	Course Category	No. of Credits	Course Code	Course
SEM-III	Open Elective	3	PA253351	Intellectual Property Rights
			PA253352	Entrepreneurship Development
			PA253353	Engineering Economics

Multi-Disciplinary Minor (MDM)

Semester	Course Category	No. of Credits	Course Code	Course
SEM-III	Multi-Disciplinary Minor	3	PA253201	Automotive Electronics
			PA253202	Electric and Hybrid Vehicles
			PA253203	Automated Guided Vehicles

Course Title: Automotive Systems **Course Code: PA251001** **Course Category: PCC**		
Teaching Scheme	**Examination Scheme**	
Lectures: 04 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 04	MSE	20 Marks
Semester: First Year (Semester-I)	ESE	60 Marks

Course Prerequisite: 1. Basic knowledge of automotive vehicle layout, IC engines, transmission system, suspension, steering and braking system. 2. Kinematics, dynamics, vibrations, and essential engineering mathematics. 3. Basic manufacturing processes and exposure to CAD/CAE for design analysis.

Course Description:

This course provides an in-depth study of automotive vehicle systems and design aspects with emphasis on chassis, body, transmission, steering, suspension, and braking systems. Students will learn constructional details, materials, design considerations, and recent advances such as automatic transmission, active suspension, ABS, and electronic stability control.

Course Objectives:

1. To provide knowledge of constructional details, materials, and design considerations of automotive body, chassis, transmission, steering, suspension, and braking systems.
2. To explain the selection and design aspects of clutches, gearboxes, brakes, and suspension components.
3. To introduce modern automotive technologies such as automatic transmission, active suspension, ABS, EBD, and electronic stability control.
4. To prepare students for research and industry applications in automotive system design through practical exposure and problem-solving skills.

Course Outcomes:

Cos	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall types, layouts, and constructional details of body, chassis, clutch, gearbox, steering, suspension, and braking systems.	L1 Remember
CO2	Explain working principles, materials, and design considerations of major automotive systems.	L2 Understand
CO3	Apply design procedures for gear ratios, braking force, suspension, and steering geometry.	L3 Apply
CO4	Analyze frame loads, steering geometry, suspension behavior, and braking performance.	L4 Analyze
CO5	Evaluate advanced technologies like automatic transmission, ABS, EBD, active suspension, and stability control.	L5 Evaluate

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc.
CA-2 (b)	Model Making / Assignment / Presentation / etc.
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Automotive Body and Types of Chassis** Car Body: Types, Constructional details, material, and 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.	7hrs
Unit 2	**Automotive Clutch** 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.	7hrs
Unit 3	**Automotive Gearbox** 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)	7hrs
Unit 4	**Steering System** 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 Under steer, Over steer, Neutral Steer, Conditions for true rolling motion of wheels, Types of steering systems, Four-wheel steer, Steer by wire. (Numericals on Ackermann angle)	7hrs
Unit 5	**Suspension Systems** 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:	7hrs
Unit 6	**Braking Systems** 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)	7hrs

Reference Books	
1.	Crouse W.H, "Automotive chassis and body" (1971), McGraw-Hill, New York.
2	Gento., Giancarlo., Morello., "The Automotive chassis", (2009), Springer.
3	Naunheimer, H., Bertsche, B., Ryborz, J., Novak, W. "Automotive Transmissions- Fundamentals, Selection, Design and Application", Springer-ISBN 978-3-642-16214-5, 2011.

Text Books	
1	R.K. Rajput, "A Text–Book of Automobile Engineering",(2010),Laxmi Publications Private Limited
2	Kirpal singh ,"Automobile Engineering" "standard publishers, Distributors, Delhi, 1999.

Web Resources	
1	Prof.C.S.ShankarRam—FundamentalsofAutomotiveSystems,NPTEL/SWAYAM,IIT Madras, 2021 NPTEL: Fundamentals of Automotive Systems – NPTEL
2	Course: Engine System and Performance, Prof. Pranab K. Mondal, IIT Guwahati https://online courses. nptel. ac. In/noc25_me19/preview

Course Title: Vehicle Dynamics **Course Code: PA251002**	**Course Category: PCC**	
Teaching Scheme	**Examination Scheme**	
Lectures: 04 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 04	MSE	20 Marks
Semester: First Year (Semester I)	ESE	60 Marks

Course Prerequisite:

Vehicular Systems, Automotive Components, Single Degrees of Freedom Systems.

Course Description:

This course covers the fundamental dynamics of vehicle tyres, including their types, materials, and performance characteristics under various forces. It explores road load effects such as aerodynamic drag, rolling resistance, and gradient resistance, and their impact on vehicle performance. Vehicle ride dynamics are analyzed through excitation sources and ride models, emphasizing suspension behavior and control. Steering and suspension systems are studied with focus on geometry, handling characteristics, and load distribution. Vehicle stability during cornering, braking, and turning is examined alongside mechanical vibration theory for system dynamics. Overall, the course integrates vehicle dynamics principles to enhance understanding of ride comfort, safety, and handling.

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:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall the fundamental concepts, definitions, and terminology related to tyre dynamics, road loads, suspension, steering geometry, vehicle ride models, and mechanical vibrations.	L1 **Remember**
CO2	Explain the working principles and functions of tyres, suspension and steering systems, vehicle response characteristics, and the impact of dynamic forces on vehicle handling and comfort.	L2 **Understand**
CO3	Apply standard models, equations, and theoretical principles to analyze road loads, vehicle ride characteristics, steering behavior, and vibration responses in typical engineering problems.	L3 **Apply**
CO4	Analyze the influence of design parameters, excitation sources, and dynamic responses on vehicle handling, ride comfort, and stability under various operating conditions.	L4 **Analyze**
CO5	Evaluate the performance of vehicle systems with respect to tyre-road interaction, vibration isolation, and stability criteria, and justify design decisions based on dynamic and vibration analysis.	L5 **Evaluate**

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / Assignment.
CA-2 (b)	Model Making / Assignment / Presentation.
MSE (c)	Mid Sem Examination

Course Contents

Unit 1	**Tyre Dynamics:** 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.	8 Hrs
Unit 2	**Road Loads:** 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**.**	10 Hrs
Unit 3	**Vehicle Ride Characteristics:** 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.	8 Hrs
Unit 4	**Steering and Suspension System:** 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.	10 Hrs
Unit 5	**Vehicle Stability:** 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	6 Hrs
Unit 6	**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.	6 Hrs

Reference Books	
1.	Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, Publisher: Society of Automotive Engineers Inc., 2nd Edition, 2021.
2	Bruce P. Minaker & Martin Meywerk, Fundamentals of Vehicle Dynamics and Modeling: A Textbook for Engineers With Illustrations and Examples, Wiley Publication, 1st Edition, 2019.
Text Books	
1.	Reza N Jazar, Vehicle Dynamics: Theory and Application, Springer International Publishing AG, 1st Edition, 2019.
2	Heins Heisler, Advanced Vehicle Technology, Butterworth-Heinemann Publication, 2nd Edition, 2002.

Web Resources	
1.	Full Vehicle Modeling System. (https://www.youtube.com/watch?v=LN6tFy0_NTE)

Course Title: Automotive Materials **Course Code: PA251003**	**Course Category: PCC**	
Teaching Scheme	**Examination Scheme**	
Lectures: 04 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 04	MSE	20 Marks
Semester: First Year (Semester I)	ESE	60 Marks

Course Prerequisite: Chemistry, Material Science.

Course Description:

This course introduces the classification, selection, and applications of materials used in automotive components. It covers metallic, non-metallic, and modern materials, highlighting their properties, merits, and limitations. Students will also learn about strengthening mechanisms, failure analysis, and remedies for material-related issues in automobiles.

Course Objectives:

1. Provide knowledge of classification, properties, and selection criteria of materials for automotive components.
2. Explain the role of metallic, non-metallic, and advanced materials in improving vehicle performance
3. Develop the ability to apply material selection principles in designing various automotive parts.
4. Analyze the suitability of modern materials such as composites, smart materials, and high-temperature materials for automotive applications.
5. Introduce methods of failure analysis and remedies from a material and process perspective.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	List different types of automotive materials, their properties, uses, and common failure modes.	L1
CO2	Explain how material properties, strengthening methods, and selection factors affect automotive parts.	L2
CO3	Use material selection principles to choose proper materials for engine, transmission, and structural components.	L3
CO4	Compare and analyze metallic, non-metallic, and modern materials for strength, weight, and performance.	L4
CO5	Judge the reasons for material failures in automotive parts and suggest suitable remedies.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc
CA-2 (b)	Model Making / Assignment / Presentation / etc
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Classification and Selection of Material for Automotive Components:** 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, crank case cam, cam shaft, engine valve, gear wheel, clutch plate, axle, etc.	7 Hrs
Unit 2	**Metallic Materials for Automotive Components:** 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.	7 Hrs
Unit 3	**Non-metallic Materials for Automotive Components:** Polymers and Properties of polymers, Need, Properties, and applications of Thermoplastic, thermo sets and Ceramics in Automotive Components, Merits, limitations, and Remedies of non-metallic materials in automotive Components.	7 Hrs
Unit 4	**Ferrous Materials and Non Ferrous Materials:** **Ferrous Materials:** Steels: plain carbon steels, alloy steels, stainless steels, HSLA steels. Cast irons: gray, ductile, malleable, and compacted graphite irons. Properties, applications, and limitations of ferrous materials in engine blocks, gears, chassis, and suspension. **Non Ferrous Materials:** Light alloys: aluminum, magnesium, and titanium alloys – properties, applications, and challenges. Copper and nickel alloys in automotive electrical and thermal systems.	7 Hrs
Unit 5	**Modern Materials for Automotive Components:** Composite Materials, Metal-Matrix composites, Ceramic-Matrix Composites, Fiber reinforced Polymers or Fiber Glass, Advanced Composites, Carbon Fiber, Smart Materials, Shape Memory Alloys. Sensors and High Temperature Materials for Automotive Applications.	7 Hrs
Unit 6	**Failure Analysis of Automotive Component:** Material selection for engine components, transmission parts, suspension, and structural members. Methods of failure analysis: visual inspection, NDT, SEM, metallography, fracture mechanics. Remedies for material failures: redesign, material substitution, coatings, surface treatments.	

Text/Reference Books	
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	W. D. Callister. (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.

Text Books	
1.	M. P. Groover. (2005) Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.
2	S. Kalpakjian and S. R. Schmid. (2003) Manufacturing Engineering and Technology, Pearson Education.

Web Resources	
1.	Welding Of Advanced High Strength Steels For Automotive Applications — Prof. Murugaiyan Amirthalingam, IIT Madras NPTEL Link: https://onlinecourses.nptel.ac.in/noc23_mm34/preview NPTEL
2	Basics of Materials Engineering — Prof. Ratna Kumar Annabattula, IIT Madras NPTEL Link: https://onlinecourses.nptel.ac.in/noc22_me90/preview

Course Title: Automotive Electronics **Course Code: PA251101**	**Course Category: PEC-I**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester-I)	ESE	60 Marks
Course Prerequisite: Basics of Automobile Engineering, Basics of Electronics Engineering		

Course Description:

This course provides the principles, design and applications of electronics in modern automobiles; it covers fundamentals of automotive sensors, actuators, control unit communication protocols, power electronics and electronic control subsystems such as engine management, braking, transmission, and safety systems. Students will gain insight into system integration, fault diagnostics, and engineering technologies like hybrid electric vehicle systems, the course emphasizes both theoretical concepts and practical applications for vehicle performance and safety and efficiency.

Course Objectives:

1. To provide fundamental of automotive electronics systems and their roles in automotive systems
2. Explain the working principles of sensors, actuators and controls used in automobile applications
3. Developing understanding in vehicle communication networks (LIN Can Flex Ray Ethernet) and Diagnostic protocols.
4.Introduce electronics engine management system emission control and power train electronics
5. enable student to apply microcontroller, embedded system, and digital signal processing to automotive applications
6. familiarize students with recent technologies in automotive systems such as ADAS, vehicle Autonomy, prognostics, health monitoring etc.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall the fundamental terminology, classifications, and specifications of automotive sensors, engine management components, chassis systems, communication protocols, warning devices, and modern trends.	L1
CO2	Explain the working principles, functional architecture, and interrelationships of mechatronic components, electronic control units, multiplexing networks, diagnostic systems, and intelligent vehicle technologies.	L2
CO3	Apply electronic and control engineering principles to select appropriate sensors, actuators, management strategies, communication buses, and safety features for specific automotive applications.	L3
CO4	Analyze the operational behavior and signal characteristics of engine controllers, chassis safety systems, in-vehicle networks, and driver information systems under various dynamic and fault conditions.	L4
CO5	Evaluate the overall performance and suitability of integrated automotive systems by assessing sensor accuracy, control logic efficiency, network reliability, diagnostic data, and adherence to modern safety standards.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc
CA-2 (b)	Model Making / Assignment / Presentation / etc
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Sensors and Actuators:** 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.	6 Hrs
Unit 2	**Electronic Engine Management system:** 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.	6 Hrs
Unit 3	**Electric Management System and Dashboard Instrumentation:** 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, future automotive electronic systems, Chassis Systems: ABS, TC, ESP, TPMS, Active Suspension, Active Steering system.	6 Hrs
Unit 4	**Automotive Tools, Diagnosis & Networking:** 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.	6 Hrs
Unit 5	**Warning and Alarm Instruments:** Brake actuation warning system, low tire pressure warning system, driver information system, traficators, 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.	6 Hrs
Unit 6	**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).	6 Hrs

Reference/Text Books	
Reference Books	
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 KonradReif, Springer Fachmedien Wiesbaden, 2014.
4	Understanding Automotive Electronics, Wiliam B. Ribbens, 5th Edition, Newnes, Butterworth Heinemann.
5	William B.Ribben, Understanding Automotive Electronics (2003), 6th ed., Elsevier Science.
Text Books	
1.	WiiliamRibbens , understanding automotive electronics, 8th edition, butterworth- Hienemann,2017
2	Tom Denton, Automobile Electronics systems, 5th edition, Rutledge, 2017
3.	NazmuzZaman, Automotive Electronics Design Fundamentals, Springer 2015.

Web Resources	
1.	https://nptel.ac.in/courses/112103617?utm
2	https://nptel.ac.in/courses/108108147

Course Title: Vehicle Maintenance and Diagnostics **Course Code: PA251102** **Course Category: PEC-I**		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester I)	ESE	60 Marks

Course Prerequisite: Fundamental Knowledge of Basic Mechanical Engineering concepts from various courses like Strength of materials, thermodynamics, fluid mechanics, Automobile Engineering Basics like vehicle layout, chassis, engine, transmission, suspension, braking, steering systems. Knowledge of fundamental concepts in Electrical & Electronics principles, laws, and systems. Knowledge of basic systems like DC/AC circuits, wiring, batteries, alternators, sensors, actuators.

Course Description: The subject deals with the study of methods, tools, and techniques used to detect, analyze, and rectify faults in vehicles to ensure safe, efficient, and reliable operation and maintenance of vehicles for their best and healthy performance. This course provides an in-depth study of modern automotive diagnostic procedures. Students will move from foundational concepts to advanced strategies for identifying and resolving complex vehicle faults. The curriculum emphasizes a logical, systematic approach to troubleshooting using service information, diagnostic scan tools, digital multimeter, oscilloscopes, and other specialized equipment. Key areas of focus include engine performance, electrical systems, networks, and electronic controls. Safety and professional standards are integrated throughout

Course Objectives: In this course learning students will:

1. Know various service, repair and maintenance processes and tools required.
2. Develop diagnostic skills and apply a structured diagnostic process to identify vehicle malfunctions.
3. Apply maintenance practices and troubleshoot complex engine performance, electrical, and drivability concerns.
4. Use modern diagnostic technologies, document diagnostic findings and repair procedures professionally.
5. Ensure vehicle safety and achieve best performance of vehicle.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Know and Remember the importance of vehicle maintenance, service and Safety.	L1
CO2	Understand maintenance and diagnostics and Various methods and tools for Diagnostics.	L2
CO3	Identify, analyze and solve problems and faults related to vehicle engines and its sub-system	L3
CO4	Inspect, evaluate and repair battery and charging systems of vehicles for signs of wear, damage, or malfunction.	L4
CO5	Inspect, evaluate, examine and solve or suggest advanced solutions for any miner or accessory component issues.	L4
CO6	Evaluate and suggest remedies for remote intricate faults in electrical, electronic components and circuits.	L4

CO-PO Mapping

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	1	1							2	2	3	2	2
CO2	3	1	1		3					2	2	3	2	1
CO3	3	3	3	3	3					2	2	3	2	2
CO4	3	3	3	3	3					2	2	3	2	2
CO5	3	3	3	3	3					2	2	3	2	1
CO6	3	3	3	3	3					2	2	3	2	2

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc.
CA-2 (b)	Model Making / Assignment / Presentation / etc.
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**INTRODUCTION TO MAINTENANCE, SAFETY** Need for maintenance, types of maintenance: preventive and breakdown maintenance, requirements of maintenance, preparation of check lists. Inspection schedule, maintenance of records, log sheets and other forms, safety precautions in maintenance: General safety, tool safety.	6 Hrs
Unit 2	**INTRODUCTION TO DIGNOSTICS, TOOLS AND TECHNIQUES** The Six-Step Diagnostic Process, Mastering Service Information, Diagnostic Techniques, diagnostic process, diagnostics on paper - mechanical diagnostic techniques, electrical diagnostic techniques, fault codes, on and off-board diagnostics, Data sources. **Basic equipment's**- Oscilloscopes, Scanners, and Scan Tools: Code Readers vs. Bi-Directional Scanners Fault code readers, Engine Analyzers – Sensors, Actuators.	6 Hrs
Unit 3	**ENGINE PERFORMANCE DIAGNOSTICS** **Dismantling, inspection, service of engine components**: Cylinder head, valve train, cylinder block, connecting rod, piston and crankshaft assembly; cleaning inspection and Servicing of other accessory engine components like fuel system, fuel Injection system, cooling system: water pump, radiator, thermostat. Lubrication system and reconditioning of these components. Engine tune-up, Anticorrosion and anti-freeze additives. Air Induction and Exhaust Diagnostics- Diagnosing vacuum leaks, exhaust restrictions, and EGR system faults. Identifying types of misfires (mechanical, ignition, fuel, and compression), using power balance tests, scope patterns, and live data**.**	6 Hrs
Unit 4	**DIAGNOSTICS OF BATTERY AND CHARGING SYSTEM – Battery Diagnosis and Troubleshooting**: Identifying common battery and Charging system related issues, Symptoms of a weak or faulty battery, diagnosing battery drain or parasitic draw, Different trouble causes and remedies of the battery and Charging system., Topping up electrolyte (for lead acid battery). **Battery Testing**: Various terminology used for battery testing. -Voltage measurement using a multimeter, Load test, Hydrometer test, Cadmium test. And testing via battery analyzer. Battery Charging and jump start: Various charging processes and their use. Step-by-step process of connecting jumper cables correctly and safely. Checking and setting ignition timing, Testing of ignition system using oscilloscope, Testing of all components of ignition system, Testing of spark plug.	6 Hrs
Unit 5	**MAINTENANCE, DIAGNOSTICS AND TESTING OF OTHER COMPONENTS OF VEHICLE**: 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 diagnostic, Air bags and belt tensions diagnostics. Checking Control circuit test, Starter circuit voltage drop test, Starter amperage test, Starter motor field coil, growler armature and run out test, Charging voltage test, Drive belt inspection and adjustment. AC ripple voltage & current test, Voltage drop test, Alternator output test.	6 Hrs

Unit 6	**ELECTRICAL SYSTEM, ELECTRONIC COMPONENTS AND CIRCUIT DIAGNOSIS** Importance of Diagnosis Trouble Codes (DTCs) in Vehicle Diagnostics, Detailed information of various sensors OBD fault codes and its interpretation. Engine related fault codes, Transmission system related fault codes. Emission related fault codes, Passive restraint system related fault codes, Diagnosis and troubleshooting of various vehicle electrical Auxiliary Systems. -Windscreen washers and wipers, signaling circuits, Horns, Engine cooling fan motors, electric window, lighting circuit etc., HVAC diagnostics, Cruise control diagnostic**,** Fuel cells, Thermoelectric energy, Thermionic power generation, Thermodynamic devices magneto hydrodynamic generations, Photovoltaic cells	6 Hrs

Text/Reference Books	
Text Books	
1.	Automotive Service: Inspection, Maintenance, Repair. by Tim Gills.
2	Advanced automotive fault diagnosis by. Tom Denton
3	Kirpal Singh, Automobile Engineering, Volume 1& 2, Standard Publishers distributor, 2014
4	Automotive maintenance and trouble shooting. By Ernest A. Venk, Edward Dale Spicer & Irving.
5	Automotive Technician Training, Taylor and Francis, New York, 2015
	Reference Books
1	Service Manuals from Different Vehicle Manufacturers
2	Automotive Technology: Principles, Diagnosis, and Service, James D. Halderman, Chase D. Mitchell Jr.

Web Resources	
1.	Full Vehicle Modeling System. (https://www.youtube.com/watch?v=LN6tFy0_NTE)

Course Title: Automotive HVAC **Course Code: PA251103**	**Course Category: PEC-I**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester I)	ESE	60 Marks

Course Prerequisite: Thermodynamics , Refrigeration & Air conditioning, Basic Automobile Engineering

Course Description: An Automotive HVAC course provides knowledge and hands-on skills for maintaining, diagnosing, and repairing vehicle heating, ventilation, and air conditioning systems, covering fundamental principles, components like compressors and condensers, the refrigeration cycle, system malfunctions, safety precautions, and modern advancements such as those in electric and hybrid vehicles.

Course Objectives:

1. To Introduce fundamental principles of refrigeration and air conditioning and familiarize HVAC systems with various types of HVAC Systems.
2. To provide knowledge of HVAC components, controls and their integration with emphasis on requirements in HVAC application.
3. To develop the ability to formulate and analyze the mathematical models for different HVAC components.
4. To impart skills for diagnosing the operational problems in HVAC and select appropriate maintenance strategy
5. To enable students to compare the performance of different types of HVAC system for effective application and energy efficiency.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Define the basics of refrigeration and Air conditioning. Also List various HVAC System	L1
CO2	Understand HVAC system with all the components , different controls used in HVAC system & the requirements of HVAC in automobile applications	L2
CO3	Develop Mathematical Models for different HVAC components	L3
CO4	Diagnose the problems with HVAC systems, identification of proper maintenance strategy.	L4
CO5	Evaluate the Performance of Various HVAC systems.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc.
CA-2 (b)	Model Making / Assignment / Presentation /etc.
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction**- 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.	6 Hrs
Unit 2	**AC Control Devices:** 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.	7 Hrs
Unit 3	**Refrigerants & Air Management Systems:** Refrigerants used their properties & relation between Temperature and pressure relation, computability with lubricant oil, handling of refrigerants. 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	8 Hrs
Unit 4	**Modeling of Air-Conditioning Components:** 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.	6 Hrs
Unit 5	**Diagnosis and Maintenance of HVAC system:** 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.	6 Hrs
Unit 6	**Environmental Considerations and energy efficiency rating:** Understanding environmental regulations regarding refrigerants, The major inefficiency and losses in HVAC systems, Star rating in HVAC systems.	3 Hrs

Reference Books	
1	Goings L. F. "Automotive Air-conditioning" , American Technical services.
2	Paul wiser "Automotive Air-conditioning", Reston publishing Co inc 1990.
3	Boice H. Dwiggins jack erjavec, "Automotive Heating Air-conditioning" Delmer Publisher 2001
4	William H course and Donald L Anglin "Automotive Air-conditioning" Mc-Graw H Hill Inc.
Text Books	
1	Refrigeration and Air condition by R K Rajpuj
2	Refrigeration and Air condition by C. P. Arora
3	Refrigeration and Air condition by R. S. Khurmi

Web Resources	
1	Refrigeration and Air condition https://nptel.ac.in/courses/112107208

Course Title: Vehicle Aerodynamics **Course Code: PA251104**	**Course Category: PEC-II**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester I)	ESE	60 Marks
Course Prerequisite: Fluid Mechanics		

Course Description:

This course provides an in-depth understanding of the principles and applications of vehicle aerodynamics. It covers the fundamental fluid dynamics concepts governing airflow around vehicles, the impact of aerodynamic forces on vehicle performance, stability, safety, and comfort. The course also explores techniques for optimizing vehicle body shapes to reduce drag and improve fuel efficiency, with special focus on high-performance and commercial vehicles. Experimental methods including wind tunnel testing and numerical approaches like Computational Fluid Dynamics (CFD) are introduced to analyze and enhance vehicle aerodynamic performance.

Course Objectives:

1. To explain the fundamental aerodynamic principles and fluid dynamics concepts applicable to vehicle design.
2. To analyze various aerodynamic forces and resistances affecting vehicle motion and performance.
3. To apply body shape optimization techniques to minimize drag and enhance fuel economy.
4. To evaluate the effects of aerodynamic phenomena on vehicle stability, safety, and passenger comfort.
5. To utilize experimental and numerical methods, including wind tunnel testing and CFD, for aerodynamic analysis of vehicles.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall key concepts, formulas, and types of drag, vehicle shapes, flow types, stability factors, noise sources, and testing methods in vehicle aerodynamics.	L1
CO2	Explain how aerodynamic forces, body shapes, flow patterns, stability, noise, and experimental tools affect vehicle performance and design.	L2
CO3	Use aerodynamic principles and shape optimization methods to improve vehicle drag, stability, safety, comfort, and fuel efficiency.	L3
CO4	Analyze airflow, drag components, vehicle behavior, noise sources, and test data to identify aerodynamic issues and effects.	L4
CO5	Evaluate vehicle designs, stability, drag reduction strategies, and testing methods to suggest improvements in performance and safety.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc.
CA-2 (b)	Model Making / Assignment / Presentation / etc.
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Fundamentals of Vehicle Aerodynamics** 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)	5 Hrs
Unit 2	**Aerodynamic Forces and Resistances** Aerodynamic forces and moments affecting vehicles, Resistances to vehicle motion: 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: form drag, skin friction drag, induced drag, Analysis of aerodynamic drag and drag fractions of cars	5 Hrs
Unit 3	**Body Shape Optimization and Drag Reduction** Strategies for body shape development to reduce drag and improve fuel efficiency, 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 performance, Effects of gap configurations, fasteners, side panels, and spoilers, Case studies on drag reduction and body shape optimization	7 Hrs
Unit 4	**Directional Stability, Safety, Comfort, and Aero acoustics** 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 odor removal, Influence of airflow on the interior and exterior noise of motor vehicles, Aerodynamic noise generation, main noise sources, and options for their reduction	7 Hrs
Unit 5	**Aerodynamics of High-Performance and Commercial Vehicles** Aerodynamic considerations for high-performance vehicles, Design and placement of front wings and rear wings, Effects of weight distribution on aerodynamics: oversteer, understeer, center of gravity, Slipstreaming techniques and aerodynamic benefits, Aerodynamic drag and fuel consumption in commercial vehicles (trucks, buses), Strategies for reducing drag in heavy-duty vehicles, Aerodynamic features of high-performance vehicles: spoilers, diffusers, and air dams	6 Hrs
Unit 6	**Experimental and Numerical Vehicle Aerodynamics** Wind tunnel fundamentals, Design and working principles of wind tunnels, Types of wind tunnels: open-circuit, closed-circuit, and automotive wind tunnels, Measurement and testing techniques, Transducers for measuring aerodynamic forces and moments, Pressure and airflow velocity measurements, Flow visualization techniques, Numerical methods and CFD for vehicle aerodynamics	6 Hrs

Sr.No.	Textbooks
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. YomiObidi, "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.

	Web Resources
1.	Fundamentals of Theoretical and Experimental Aerodynamics, IIT Kharagpur, NPTEL, https://nptel.ac.in/courses/101105088
2.	***Introduction to Vehicle Dynamics*** **— Dr. R. Krishnakumar, IIT Madras (covers aerodynamics topics among vehicle dynamics) NPTEL** **Course Link:https://nptel.ac.in/courses/107106080**

Course Title: Finite Element Method		
Course Code: PE251105	**Course Category:** PE II	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs./ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester-I)	ESE	60 Marks

Course Prerequisite: Students should have a basic understanding of Strength of Materials and Engineering Mechanics, along with familiarity with structural and thermal engineering problems, and should also possess knowledge of differential equations and numerical methods relevant to engineering analysis.

Course Description: This course introduces the Finite Element Method (FEM) as a numerical technique for solving structural, thermal, and mechanical engineering problems. It covers fundamental principles, vibrational methods, 1D bars, trusses, and beams, 2D triangular and quadrilateral elements, isopararmetric formulations, and 3D solids, along with plates, shells, dynamic, and stability analysis. Emphasis is on stiffness matrix derivation, shape functions, convergence, accuracy, and practical FEM software applications, enabling students to model, analyze, and solve real-world engineering challenges efficiently.

Course Objectives:

1. Provide a fundamental understanding of FEM principles, historical development, and applications in engineering analysis.
2. Develop the ability to formulate mathematical models for engineering problems using variational principles, energy methods, and weak formulations.
3. Train students to solve 1D a structural and thermal problem, including bars, trusses, and beams, using FEM techniques.
4. Enable derivation of element stiffness matrices, application of shape functions, and assembly of global system matrices.
5. Familiarize students with FEM formulations for 2D and 3D problems, including plane stress/strain, isopararmetric elements, plates, shells, and practical modeling considerations.
6. Equip students to use FEM software effectively for modeling, mesh generation, dynamic and stability analysis, and post-processing of engineering problems.

Course Outcomes:

COs	**After completion of the course: Students should be able to**	**Bloom's Level**
CO1	Describe the fundamental principles of FEM, linear elasticity, variational principles, and approximate solution techniques	L1
CO2	Interpret and construct mathematical models of engineering problems using energy methods, weak forms, and boundary condition formulations	L2
CO3	Apply FEM techniques to formulate and solve 1D structural and thermal problems including bar, truss, and beam systems	L3
CO4	Analyze stiffness matrices, shape functions, and isopararmetric formulations for 2D and 3D problems, including convergence, patch test, and stress recovery	L4
CO5	Evaluate FEM results for accuracy, convergence, stability, and practical applications in plate, shell, and dynamic systems	L5
CO6	Create FEM models for 3D, dynamic, and advanced engineering problems using software tools, including mesh refinement and practical simulations	L6

CO-PO Mapping

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	1	1	1	1				1	2	1		
CO2	3	3	2	2	2	1		1		2	2	2	1	2
CO3	2	2	2	2	3	2		2		1	2	2	2	2
CO4	3	3	3	3	3	2		2		2	3	3	2	2
CO5	3	2	3	3	3	2		2		2	3	3	[illegible]	2
CO6	3	3	3	3										

Assessment	
CA-1 (a)	Subjective Test
CA-2 (b)	Assignment
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction & Variational Principles** Overview of FEM, Historical development, Significance and comparison with other numerical methods, Variational formulations, Rayleigh-Ritz method, Galerkin method, Weak formulation, Boundary conditions, Applications in structural, thermal, and fluid mechanics	6Hrs.
Unit 2	**1D Structural and Thermal Analysis** 1D Structural Problems: bars and trusses, 1D Thermal Problems: heat conduction in rods and fins, Shape functions: linear and quadratic interpolation, Element Matrices: stiffness and load matrices, Assembly and Solution of global matrices	6 Hrs.
Unit 3	**2D Structural Analysis** Plane stress and plane strain problems, 2D shape functions: linear and higher-order triangular elements, Isopararmetric formulation, Numerical integration: Gauss quadrature, Stress recovery techniques, Treatment of boundary conditions and body forces	6 Hrs.
Unit 4	**3D Structural Analysis and Advanced Topics** 3D Solid Elements formulation and application, Axisymmetric problems, Mixed formulations: incompressible and nearly incompressible materials, Dynamic analysis: lumped and consistent mass matrices, modal analysis, Stability analysis: buckling techniques	6 Hrs.
Unit 5	**FEM for Plates and Shells** Plate bending: Kirchhoff-Love and Reissner-Mindlin theories, Shell structures: concepts and applications, Finite element formulation for plates and shells, Boundary conditions, Practical modeling tips and common pitfalls	6 Hrs.
Unit 6	**FEM Software and Practical Applications** FEM software introduction, Modeling workflow, Mesh generation, post-processing and result interpretation, Common pitfalls, Troubleshooting and validation techniques	6 Hrs.

Text/Reference Books
Textbooks
R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, Concepts and Applications of Finite Element Analysis 4th Edition, 2001, John Wiley & Sons, ISBN-13: 978-0471356059
C. S. Krishnamurthy, Finite Element Method: Theory and Programming, 2nd Edition, 2006, Tata McGraw-Hill ISBN-13: 978-0074632359
Klaus-Jürgen Bathe, Finite Element Procedures, 2nd Edition, 2014, ISBN-13: 978-0979004957
Tirupathi R. Chandrupatla& Ashok D. Belegundu, *Introduction to Finite Elements in Engineering,* 4th Edition, 2012, Pearson Education, ISBN-13: 978-0132162746
Reference Books
Bruce Irons &Sohrab Ahmad, Techniques of Finite Elements, 1st Edition, 1980, Ellis HorwoodISBN-13: 978-0853121305
O. P. GuptaFinite and Boundary Element Methods in Engineering, 3rd Edition, 2004, Oxford & IBH Publishing, ISBN-13: 978-9054107651
S. S. Rao,The Finite Element Method in Engineering6th Edition, 2017, Butterworth-Heinemann ISBN-13: 978-0128117682
Olek C. Zienkiewicz& Robert L. Taylor, The Finite Element Method, 7th Edition, 2013, ElsevierISBN-13: 978-1856176330

Web Resources	
1.	NPTEL Course: Finite Element Methods
2	ANSYS Learning Resources
3	COMSOL Blog & Application Gallery
4	MIT Open Courseware: Numerical Methods / FEM

Course Title: Automotive Safety and Crashworthiness **Course Code:** PA251106	**Course Category: PEC-II**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: ----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (SEM-I)	ESE	60 Marks
Course Prerequisite: Automotive Body and Chassis Systems, Vehicle Dynamics		
Course Description: The subject Automotive Safety and Lighting focuses on the principles, design, and technologies used to enhance vehicle safety and visibility. It covers active and passive safety systems, crashworthiness, driver assistance technologies, and automotive lighting systems to ensure road safety and improved driving conditions.		

Course Objectives:

1. To provide fundamental knowledge of automotive safety by introducing the evolution, significance, and concepts of active and passive safety, along with crashworthiness goals, requirements, and testing methods.
2. To develop understanding of vehicle safety equipment and systems, including seat belts, airbags, steering systems, bumpers, mirrors, warning devices, and protection mechanisms for enhanced occupant and pedestrian safety.
3. To familiarize students with automotive lighting systems and testing instruments, focusing on principles of light measurement, standards, detectors, and the use of advanced equipment such as gonio-photometers and integrating spheres.
4. To analyze crash testing methods and injury mechanics by studying different types of collisions, crash test procedures, regulatory requirements, and human body injury mechanisms under various impact conditions.
5. To impart knowledge on collision modeling, ergonomics, and biomechanics for understanding vehicle crash dynamics, human tolerance limits, injury thresholds, severity indices, and the role of simulation and anthropometry in automotive safety design.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall the fundamental definitions, classifications, and standards related to active/passive safety, BIW materials, lighting equipment, crash test protocols, collision models, and injury biomechanics.	L1
CO2	Explain the working principles and functional requirements of safety restraint systems, lighting detectors, crashworthiness structures, collision warning devices, and anthropometric dummies.	L2
CO3	Apply regulatory standards, physics equations, and ergonomic data to determine design parameters for vehicle lighting, bumper systems, crash structures, and occupant retention systems.	L3
CO4	Analyze vehicle behavior, structural deformation, lighting distribution, and occupant injury mechanisms under various collision scenarios using impulsive models and crash test data.	L4
CO5	Evaluate the overall safety performance of a vehicle by interpreting NCAP ratings, injury severity indices, lighting test results, and crash simulation outcomes against global safety regulations.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc
CA-2 (b)	Model Making / Assignment / Presentation / etc
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction to Automotive Safety:** 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)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.	6 Hrs
Unit 2	**Vehicle Safety equipment** 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.	6 Hrs
Unit 3	**Automotive Lighting System and Testing Equipment's:** Types of Lights, Lamps, Basics of standards and detectors, spectral measurements and Calorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in the automotive field; Gonio-Photometer, Reflecto-meter, Colorimeter, Integrating sphere, types, application, coordinate system.	6 Hrs
Unit 4	**Crash Testing and Injury Mechanics** 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.	6 Hrs
Unit 5	**Vehicle Collision Models** Physics of Car collision, collision warning system, Impulsive models- central head on collision, oblique collision, collision against fixed obstacle, non central - 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.	6 Hrs
Unit 6	**Automotive Ergonomics and Injury Biomechanics:** 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 & relation with crash and modeling and simulation studies in dummy.	6 Hrs

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

Web Resources

1	*Industrial Safety Engineering* — IIT KharagpurNPTEL Online Courses Archive
2	*Fundamentals of Automotive Systems* — IIT Madras by Prof. C. S. Shankar Ram https://nptel.ac.in/courses/107106088?utm_source=chatgpt.com

Course Title: Seminar **Course Code: PA251401**	**Course Category: VSE**	
Teaching Scheme	**Examination Scheme (As Applicable)**	
Practical's/Sessions: 02 Hours/Week	CA-I	15 Marks
	CA-II	15 Marks
Semester: First Year (Semester-I)	ESE	20 Marks

Course Prerequisite:

Basic understanding of core subjects in specialization, Ability access, and interpret scientific literature. Exposure to technical report writing and presentation.

Course Description:

The M.Tech Seminar course is designed to enhance student ability to identify, analyze and present research-oriented or industry-relevant topics related to their field of specialization. It provides a platform to review recent literature, critically analyze methodologies, and effectively communicate technical concepts written and oral forms. The course emphasizes independent learning, analytical thinking presentation and interaction with peers and faculty to prepare students for research and professional careers.

Course Objectives:

1. To enhance the ability to conduct a comprehensive literature review on a selected research/technical topic.
2. To develop skills in critical analysis, organization, and synthesis of technical information.
3. To improve proficiency in technical report writing and formatting.
4. To strengthen communication skills through oral presentation and discussion.
5. To build confidence in defending technical ideas and responding to queries effectively.

Course Outcomes:

COs	**After completion of the course: Students should be able to**	**Bloom's Level**
CO1	Identify and select a relevant research topic in Mechanical Engineering through a literature survey.	L3–Apply
CO2	Analyze and summarize state-of-the-art developments in the chosen area.	L4 – Analyze
CO3	Prepare a well-structured seminar report following technical writing standards.	L5 – Evaluate
CO4	Deliver an effective oral presentation with clarity and professionalism.	L6- Create
CO5	Demonstrate the ability to answer questions, engage in discussions, and defend ideas confidently.	L5 – Evaluate

CO-PO Mapping

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

Course Content

The seminar requires each candidate to prepare a report on a topic that they and their supervisor have mutually agreed upon. This topic must be a current problem in the field of Mechanical Engineering and should have a strong research orientation. The candidate is expected to demonstrate a thorough understanding of the recent developments related to their chosen topic. Once the report is complete, the candidate will present it to an examining committee, as well as to other faculty members from the department. The PG coordinator and the Head of the Mechanical Engineering Department will form this committee to evaluate the seminar.

Assessment	
Evaluation and Examination The seminar will be evaluated out of a total of 50 marks, with 30 marks for internal assessment and 20 marks for the semester-end examination. The semester-end examination will be conducted by a committee of three faculty members. Students must submit their completed reports, which should be authenticated by both their guide and the Head of the Department. Each student will individually present their work to the committee, who will then evaluate them and award marks.	
CA-I (a)	Review-I: 15 Marks (Concept/knowledge in the topic:10 marks, Literature: 05 marks)
CA-II (b)	Review-II: 15 Marks (Report writing & Presentation: 15 Marks)
ESE (Practical/viva você (c))	20 Marks (Individual evaluation through viva voce/test:20 marks)
Total (d)	50 Marks

Course Title: PG Lab **Course Code:PA251402**	**Course Category: VSE**	
Teaching Scheme	**Examination Scheme (As Applicable)**	
Practical's/Sessions: 02 Hours/Week	CA-I	15 Marks
	CA-II	15 Marks
Semester: First Year (Semester-I)	ESE	20 Marks

Course Prerequisite:

-Fundamental knowledge of Thermodynamics and Heat Transfer
-Basics of Internal Combustion Engines
-Understanding of Energy Conversion Systems
-Undergraduate-level laboratory experience in thermal engineering

Course Description:

This laboratory course provides postgraduate students with practical exposure to performance evaluation, testing, and emission measurement of internal combustion (IC) engines. Students will gain hands-on experience in conducting variable load tests, preparing energy balance sheets, measuring performance parameters, and assessing exhaust emissions and smoke density. The course bridges theoretical knowledge with real-world testing, aligning with modern requirements of efficiency enhancement, emission control, and environmental sustainability in IC engines.

Course Objectives:

1. To impart practical knowledge of CAD modeling and assembly of automotive components using industry-standard software.
2. To develop skills in conducting performance tests on IC engines under varying load conditions.
3. To enable students to analyze the energy balance of engines and evaluate efficiency parameters.
4. To familiarize students with exhaust emission measurement techniques and compliance with PUC norms.
5. To understand and quantify smoke density in diesel engines as a parameter of combustion quality.
6. To provide hands-on exposure to the design and functional aspects of vehicle chassis systems.

Course Outcomes:

COs	**After completion of the PG Lab: Student should be able to**	**Bloom's Level**
CO1	Demonstrate a practical understanding of vehicle chassis layouts and internal combustion engine subsystems through physical inspection and study.	L2
CO2	Develop 3D models and assemblies of complex automotive components using advanced CAD software	L3
CO3	Conduct experiments using modern test rigs, exhaust gas analyzers, and smoke meters to measure engine performance and vehicle emission levels.	L3
CO4	Analyze experimental data to evaluate engine characteristics, efficiency, and energy distribution (Heat Balance) under variable operating conditions.	L4
CO5	Interpret experimental and simulation results to prepare technical reports and present findings with effective communication and teamwork.	L5

CO-PO Mapping

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

Sr. No.	List of Experiments/Activities (Any Five)	Hours
1	CAD Modeling and Assembly of Automotive Components using CATIA/PRO-E/Solid Work/ Any suitable modeling software.	2
2	Performance measurement on Single Cylinder Diesel Engine – Variable Load Test.	2
3	Evaluation of Energy Balance Sheet of Single Cylinder Diesel Engine.	2
4	Measurement of Exhaust Gas Emissions of SI 2/3/4 Wheeler Vehicle – Pollution Under Control (PUC) Test.	2
5	Measurement of Smoke Density of Diesel Engine.	2
6	Study of Chassis Systems of Vehicles	

Assessment	
CA-I (a)	Laboratory Performance & Attendance: 10% Record/Journal Submission: 10% Marks Viva-voce (during lab sessions) – 10 %
CA-II (b)	Experiment conduction, observation, and data collection – 15 % Viva Voce (Experiment-wise): 15%
ESE	End Semester Practical Examination: 40%

Text/Reference Books	
Text Books	
1	Heywood J.B., Internal Combustion Engine Fundamentals, McGraw-Hill.
2	Bureau of Indian Standards (BIS) and Automotive Research Association of India (ARAI) guidelines on emission measurement.
3	V. Ganesan, Internal Combustion Engines, McGraw-Hill Education.
4	Mathur& Sharma, Internal Combustion Engines, DhanpatRai Publications.
5	P.N. Rao, CAD/CAM: Principles and Applications, McGraw Hill.
Reference Books	
1	Saeed Moaveni, Finite Element Analysis: Theory and Application with ANSYS, Pearson.
2	Kirpal Singh, Automobile Engineering (Vol. I & II), Standard Publishers.
3	Automotive Emission Testing Standards – SAE & ARAI Guidelines.
4	Software Documentation Manuals (CATIA, Solid Works, ANSYS, Hypermesh, LS-DYNA).
5	Relevant IS/ASTM standards for exhaust gas and smoke measurement.

Course Title: Advanced Automotive Engine Technology **Course Code: PA252004**	**Course Category: PCC**	
Teaching Scheme	**Examination Scheme**	
Lectures: 04 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 04	MSE	20 Marks
Semester: First Year (Semester-II)	ESE	60 Marks
Course Prerequisite: Applied Thermodynamics		
Course Description: This course provides an in-depth study of modern automotive engine technologies, focusing on design, operation, performance enhancement, emissions control, and emerging innovations. Students will gain advanced knowledge of internal combustion engines (ICE), hybrid power trains, and alternative propulsion systems. The course emphasizes thermodynamic principles, fuel delivery systems, turbo charging, variable valve timing, emission reduction technologies, electronic engine management, and materials for high-performance applications.		
Course Objectives: 1. Review the fundamentals of IC engines, their performance, emission challenges, and efficiency aspects. 2. Familiarize students with modern fuel supply systems for SI and CI engines including gasoline, diesel, and alternative gaseous fuels. 3. Introduce advanced combustion technologies and dual-fuel/flexible fuel concepts. 4. Analyze combustion chamber designs, charge motion, and boosting systems for improved efficiency and performance. 5. Understand emission control technologies, after-treatment systems, and global emission norms. 6. Explore modern trends in IC engines including thermal management, engine electronics, hybridization, hydrogen fuel cells, and bio fuel compatibility.		

Course Outcomes:		
COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall IC engine fundamentals, performance parameters, and current technological trends.	L1
CO2	Explain modern fuel supply systems (carburetion, fuel injection, CRDI, MPFI, and GDI) and gaseous fuel supply for SI/CI engines.	L2
CO3	Apply knowledge of advanced combustion technologies (HCCI, RCCI, PPC) for efficiency and emissions improvement.	L3
CO4	Analyze the influence of combustion chamber design, charge motion, and boosting systems on engine performance.	L4
CO5	Evaluate advanced emission control and after-treatment systems with respect to Bharat Stage VI, Euro VI, and EPA standards.	L5
CO6	Assess modern engine concepts such as lean-burn, hydrogen fuel cells, bio fuel adaptation, and hybridization.	L6

CO-PO Mapping													
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2										2	2	
CO2	3	2	2		2							2	3	2
CO3	3	3	2	2	2		2					2	3	2
CO4	3	3	3	2	2							2	3	2
CO5	3	3	2	2	2	2	3	1				2	2	2
CO6	3	2	3		2	2	3	1				3	3	2

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc
CA-2 (b)	Model Making / Assignment / Presentation / etc
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Fundamentals & Engine Trends** Review of IC engine fundamentals: performance, emissions, and efficiency challenges, Current trends in automotive engine technologies, Downsizing and rightsizing concepts. Variable compression ratio engines.	8Hrs
Unit 2	**Fuel Supply System of engine:** Carburettors, Modern Carburettors, 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	8Hrs
Unit 3	**Advanced Combustion Technologies** Homogeneous Charge Compression Ignition (HCCI), Partially Premixed Combustion (PPC), Reactivity Controlled Compression Ignition (RCCI), Gasoline Direct Injection (GDI) and Diesel Direct Injection (DDI) engines, Dual-fuel and flexible fuel combustion concepts, Low-temperature combustion strategies.	8Hrs
Unit 4	**Combustion Chambers and Boosting Systems:** Combustion Chambers in SI Engines, Combustion Chambers in CI Engines (Direct and Indirect Injection), Charge Motion in Engines: Turbulence and Turbulence Generation Methods Swirl, Swirl Generation Methods Squish, Charging Methods: Supercharging Turbo charging, Turbo-compounding	8Hrs
Unit 5	**Emission Control & After-Treatment Systems:** Advanced catalytic converters (DOC, TWC, SCR, LNT), Diesel Particulate Filters (DPF) and Gasoline Particulate Filters (GPF), Exhaust Gas Recirculation (EGR) systems (high/low pressure), Emission standards: Bharat Stage VI, Euro VI, EPA norms.	8Hrs
Unit 6	**Thermal Management, Engine Electronics &Modern Trends in IC Engines:** 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, Hybridization of IC engines (series, parallel, plug-in).	8Hrs

Reference Books	
1	W.H. Crouse and A. L. Anglin, 'Automotive Emission Control', McGraw Hill Book Co.
2	Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.
3	The I. C. Engine in theory and Practice Vol.I / Teylor / IT Prof. And Vol. II
Text books	
1	V. Ganesan, Internal Combustion Engines, Tata McGraw Hill.
2	Heywood J.B., Internal Combustion Engine Fundamentals, McGraw Hill.3

Web Resources	
1.	Engine System and Performance: IIT Guwahati, https://nptel.ac.in/courses/112103617?utm
2	Advanced Thermodynamics and Combustion https://onlinecourses.nptel.ac.in/noc24
3	IC Engines and Gas Turbines https://onlinecourses.nptel.ac.in/noc22_me65/preview?utm_source=chatgpt.com

Course Title: MOOC/SWAYAM **Course Code: PM252005**		**Course Category: PCC**
Teaching Scheme	**Examination Scheme**	
Lectures: 04 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 04	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks
Course Description: This course is part of a curated set of MOOCs offered, with the specific courses selected and approved by the Board of Studies (BoS) to ensure alignment with current academic and industry standards.		

Course Title: Electric and Hybrid Vehicles **Course Code: PA252107**	**Course Category: PEC-III**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester-II)	ESE	60 Marks

Course Prerequisite: Power Electronics and Drives (undergraduate level), Electrical Machines (AC/DC machines), Control Systems (feedback & state-space basics), Basic knowledge of internal combustion engines and vehicle dynamics (desirable), Fundamentals of batteries / electrochemistry.

Course Description: This elective provides an advanced study of electric and hybrid vehicle technologies: architectures and topologies, electric machines and power electronics for traction, energy storage systems and battery management, hybrid power train design and energy management strategies, charging infrastructure and standards, and safety/reliability issues. Emphasis is on modelling, design trade-offs, control strategies, and recent industry standards and trends.

Course Objectives:

1. Introduce modern EV/HEV architectures, components and their interactions.
2. Model and analyze electric machines and power-electronic converters used in traction systems.
3. Design and evaluate energy storage systems and battery management solutions for EV applications.
4. Develop control and energy management strategies for hybrid power trains and regenerative braking.
5. Examine charging technologies, infrastructure, interoperability standards, and system safety.
6. Prepare students to evaluate trade-offs (efficiency, cost, performance, emissions) and undertake EV-related research or product development.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Explain and compare EV/HEV architectures, component functions and system-level trade-offs.	L1
CO2	Model and analyze electric machines (BLDC, PMSM, induction) and select appropriate machine-drive pairings for traction.	L2
CO3	Design or specify power-electronic converters and motor drives for EV traction including control schemes.	L3
CO4	Analyze battery technologies, estimate performance/aging, and design basic BMS functions (SoC/SoH estimation, balancing).	L4
CO5	Formulate energy management strategies (EMS) for series, parallel and series-parallel hybrids and implement regenerative braking control.	L5
CO6	Evaluate charging methods, standards (AC/DC, conductive/inductive), infrastructure challenges, and safety/functional-safety considerations.	L6

CO-PO Mapping

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	2	2		1	2	2	1		1		1	3	1
CO2	3	3	2	2	3							1	3	3
CO3	3	3	3	2	3						1	1	3	3
CO4	3	3	2	2	2	1	3	1				1	2	2
CO5	3	2	3	2	3	1	3				1	1	3	3
CO6	2	3	1		2	3	3	3		1	1	2	2	1

Assessment	
CA-1 (a)	Subjective Test / Open book test / etc
CA-2 (b)	Model Making / Assignment / Presentation / etc
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction, Vehicle Types & System-Level Architecture:** Transportation electrification drivers, environmental & economic motivations, Classification: BEV, PHEV, HEV, (series, parallel, series-parallel), fuel-cell vehicles, System blocks: energy source, energy converter (power electronics), electric machine, gearbox/transmission, auxiliary systems (HVAC, DC-DC, inverters), Performance metrics: range, efficiency, specific energy/power, vehicle dynamics basics, drive cycles (NEDC, WLTP, FTP), Preliminary design trade-offs (vehicle sizing, energy vs. power requirements)	6 Hrs
Unit 2	**Electric Machines for Traction & Modelling:** Machine types for traction: DC, Induction, PMSM, Synchronous reluctance, BLDC — pros/cons for EVs, Machine fundamentals: torque-speed characteristics, field weakening, losses and thermal limits, Dynamic modelling: dq-model, inverter-fed drive modelling, steady-state and transient performance Sizing and selection for traction motor (torque, peak power, continuous power), Cooling and packaging considerations.	6 Hrs
Unit 3	**Power Electronics and Motor Drives:** Inverter topologies: two-level, multi-level, SiC/GaN devices, DC-DC converters, bidirectional converters, Control schemes: PWM, space-vector PWM, current control (PI/PI+FF), field-oriented control (FOC), sensor less control basics, Regenerative braking implementation & energy recovery strategies, Thermal management and EMI issues in traction inverters, Sizing of filters, cabling and protection (fuses, contactors).	6 Hrs
Unit 4	**Energy Storage Systems and Battery Management:** Battery chemistries: Lead-acid, NiMH, Li-ion variants (NMC, LFP, LCO), super capacitors — energy density vs. power density vs. aging, Battery equivalent circuit modelling, dynamic behaviour under charge/discharge, thermal effects, State estimation: SoC, SoH, SOF estimation algorithms (Coulomb counting, Kalman filter, observer-based), BMS functions: cell monitoring, balancing (active/passive), thermal management, safety, cell selection & pack design, Aging mechanisms and fast-charging impacts, Hybrid storage (battery + super capacitor) for high-power applications	6 Hrs
Unit 5	**Hybrid Power train Design & Energy Management:** Hybrid topologies: series, parallel, power-split (planetary gear-based), and architectures for different use-cases, Modelling of hybrid systems and sizing for fuel economy and emissions, Energy Management Strategies (EMS): rule-based (charge-sustaining), optimization-based (ECMS), predictive control (MPC), DP for benchmarking, Control hierarchy: supervisory control, torque split, gearshift logic, Simulation tools and co-simulation with vehicle dynamics, Case studies of production HEVs (Toyota Prius power-split, common-rail PHEV examples).	6 Hrs
Unit 6	**Charging, Infrastructure, Standards, Safety & Future Trends:** Charging modes: AC vs DC, charging levels (slow, fast, ultra-fast), on-board vs off-board chargers, conductive vs wireless charging, Charging standards & protocols: IEC 62196, IEC 61851, SAE J1772, CHAdeMO, CCS, GB/T; communication standards (ISO 15118 – Plug & Charge), Grid integration: V2G, V2H, grid impacts, demand response, smart charging & metering, rooftop solar integration, Functional safety & cyber security: ISO 26262 overview, HV safety practices, interlocks, grounding, isolation monitoring, Life-cycle considerations, recycling, regulations and incentives, future trends (solid-state batteries, hydrogen/fuel cells, light weighting).	6 Hrs

Text Books	
1	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", 3rd/4th Edition
2	Chris Mi, M. A. Masrur, David Wenz hong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2nd Edition.
3	Plett, G. L., "Battery Management Systems, Volume I: Battery Modelling" and Volume II: BMS Algorithms
4	Ned Mohan / Bimal K. Bose textbooks for Power Electronics & Drives (e.g., "Power Electronics: Converters, Applications, and Design").
5	V. Ganesan, 'Internal combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2005.
6	"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	Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.
3	William B. Ribbens, "Understanding Automotive Electronics" — automotive electronics background.

Web Resources	
1	**Introduction to Hybrid and Electric Vehicles** — Dr. Praveen Kumar, Prof. S. Majhi (IIT Guwahati) https://nptel.ac.in/courses/108103009
2	**Fundamentals of Electric Vehicles: Technology & Economics** — Prof. Ashok Jhunjhunwala, Prof. Kaushal Kumar Jha, Prof. L. Kannan, Prof. PrabhjotKaur (IIT Madras) https://onlinecourses.nptel.ac.in/noc20_ee99/preview
3	**Electric Vehicles and Renewable Energy** — Prof. Ashok Jhunjhunwala, Prof. Kaushal Kumar Jha, Prof. L. Kannan, Prof. PrabhjotKaur (IIT Madras) https://onlinecourses.nptel.ac.in/noc21_ee112/preview
4	**Electric Vehicle Engineering & Development (EVEND)** — Prof. Ashok Jhunjhunwala, Prof. Kaushal Kumar Jha, Prof. L. Kannan, Prof. PrabhjotKaur (IIT Madras) https://elearn.nptel.ac.in/shop/completed-courses/execedu-closed/electric-vehicle-engineering-development-evend/

Course Title: Computer Aided Design (CAD) and Computer Aided Engineering (CAE) **Course Code: PA252108** **Course Category:** PE III		
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs./ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks
Course Prerequisite: Basic knowledge of Engineering Graphics and Engineering Mechanics, Fundamentals of Mathematics and Computational Methods, Awareness of general engineering design processes.		
Course Description: This course introduces the concepts and applications of Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) in modern product development. It emphasizes geometric modelling techniques (wireframe, surface, solid, and assembly modelling), meshing, and finite element analysis for 1D and 2D heat transfer and fluid mechanics problems. The course also focuses on accuracy and validation of CAE results by correlating computational models with experimental testing.		
Course Objectives: 1. Provide fundamental knowledge of CAD and CAE in product design and development. 2. Introduce wireframe, surface, solid, and assembly modelling concepts for engineering applications. 3. Develop skills in meshing techniques and applying finite element methods in heat transfer and fluid mechanics problems. 4. Enable students to analyse engineering problems using CAD–CAE tools. 5. Evaluate and validate CAE solutions by comparison with experimental results.		

Course Outcomes:		
COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Explain the fundamentals of product design, design process, sustainability, and the role of CAD–CAE tools	L1
CO2	Interpret wireframe and surface modelling techniques using parametric representations for engineering applications.	L2
CO3	Apply solid and assembly modelling methods (B-Rep, CSG, feature-based modelling, tolerance modelling) to develop part and assembly models.	L3
CO4	Analyze engineering problems using meshing techniques and finite element formulations for 1D and 2D heat transfer and fluid mechanics problems.	L4
CO5	Evaluate the accuracy and validation of CAE simulations using convergence tests, stress comparison, and experimental correlation.	L5

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

Assessment	
CA-1 (a)	Subjective Test
CA-2 (b)	Assignment
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Design and CAD–CAE** Importance of design, design process, embodiment design, parametric design, Industrial design, Human factors in design, sustainability in design, Design for X (DFX), Introduction to CAD and CAE, Applications of CAD and CAE, Hardware and Software in CAD and CAE.	6 Hrs.
Unit 2	**Wireframe and Surface Modelling** Wireframe modeling, Curves and surfaces: curve representation, parametric representation of analytic and synthetic curves; surface models and representations.	6 Hrs.
Unit 3	**Solid and Assembly Modeling** Solid modeling: Boundary representation, CSG, sweep representations, Octree, primitive instancing, cell decomposition, spatial occupancy enumeration, feature recognition, design by features, tolerance modeling. Assembly modeling: Representation, mating conditions, representation schemes, generation of assembly sequences.	6 Hrs.
Unit 4	**Meshing & 1D–2D FEA (CAE Applications)** Mesh topology, data structures, mesh generation algorithms, element types, quality criteria, aspect ratio, node numbering. Applications in heat transfer & fluid mechanics: 1D heat transfer elements, 2D scalar variable problems, 2D heat transfer and fluid mechanics problems.	6 Hrs.
Unit 5	**Accuracy & Validation of FEA (CAE)** Validation and accuracy of FEA results, computational accuracy: strain energy norm, residuals, reaction forces and moments; convergence tests, stress difference. Correlation with experiments: strain gauging-stress comparison; natural frequency comparison; dynamic response comparison, temperature and pressure distribution.	6 Hrs.
Unit 6	**Advanced Applications of CAD–CAE:** Introduction to 3D meshing and higher-order elements, Overview of 3D FEA applications (structural, thermal, CFD, crash, fatigue), Optimization in CAE – shape, topology, and design optimization, CAD–CAE integration and Product Lifecycle Management (PLM), Role of CAD–CAE in Industry 4.0 and digital twins Case studies and industrial applications (automobile, aerospace, biomedical, additive manufacturing)	6 Hrs.

Sr. No	Text/Reference Books
	Textbooks
1	Ibrahim Zeid and R. Siva subramanian, CAD/CAM: Theory and Practice, 2nd Edition, McGraw-Hill Education, 2009.
2	Ibrahim Zeid, Mastering CAD/CAM, 1st Edition, McGraw-Hill Education, 2005.
3	Gerald Farin, Curves and Surfaces for CAGD: A Practical Guide, 5th Edition, Elsevier, 2002 (Reprint 2013).
4	Michael E. Mortenson, Geometric Modeling, 3rd Edition, Industrial Press, 2006.
Sr. No	**Reference Books**
1	David F. Rogers and J. Alan Adams, Mathematical Elements for Computer Graphics, 2nd Edition, McGraw-Hill Education, 1990.
2	Singiresu S. Rao, The Finite Element Method in Engineering, 6th Edition, Butterworth–Heinemann, 2017.
3	Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, 4th Edition, Prentice Hall of India (PHI), 2012.
4	Bruce Irons and Soharab Ahmed, Techniques of Finite Elements, 1st Edition, John Wiley & Sons, 1980.

Web Resources	
1	**Overview of CAD/CAM** — Prof. S. K. Saha (IIT Kharagpur) https://nptel.ac.in/courses/112102102
2	**Computer Aided Engineering Design** — Dr. Anupam Saxena (IIT Kanpur) https://nptel.ac.in/courses/112104031
3	**Finite Element Method and Computational Structural Dynamics** — Prof. Manish Shrikhande (IIT Roorkee) https://onlinecourses.nptel.ac.in/noc22_ce95/preview
4	**Rapid Manufacturing** — Prof. J. Ramkumar& Prof. Amandeep Singh (IIT Kanpur) https://onlinecourses.nptel.ac.in/noc25_me125/preview

Course Title: Automotive System Design **Course Code: PA252109**	**Course Category:** PE III	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs./ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks

Course Prerequisite: Graduate-level courses in Mechanical Engineering / Automotive Engineering fundamentals (Vehicle Dynamics, Internal Combustion Engines / EV fundamentals, Control Systems, CAD/CAE basics). Knowledge of thermodynamics, strength of materials, basic electronics, MATLAB/Simulink.

Course Description: This course provides an integrated, systems-level approach to the design of automotive subsystems and complete vehicles. It covers design methodology, system decomposition, requirements capture, trade-off analysis, multidisciplinary optimization, controls integration, safety and reliability, NVH and packaging, and model-based design. Students learn to translate customer, regulatory and performance requirements into engineering specifications, perform concept selection and detailed design, and evaluate system-level performance using simulation, prototyping and testing methods. Emphasis is on practical, contemporary automotive systems (power train, chassis, steering, braking, thermal management, electrical/electronic and body systems) and their interactions.

Course Objectives:

1. Understand systems engineering methodology and its application to automotive system design.
2. Capture and translate stakeholder, regulatory and functional requirements into engineering specifications for automotive systems.
3. Perform concept generation, trade-off analysis and optimization for automotive subsystems.
4. Integrate mechanical, thermal, and electrical and control aspects to design reliable, safe and manufacturable automotive systems.
5. Use model-based simulation tools for design validation and prototype testing strategies.
6. Apply design-for-manufacture, life-cycle, cost and sustainability considerations in automotive system design.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Describe systems engineering lifecycle and requirement management for automotive systems.	L2
CO2	Translate performance and regulatory requirements into subsystem specifications	L3
CO3	Generate and evaluate multiple concepts using trade-off analysis and selection methods	L5
CO4	Integrate mechanical, electrical and control components to develop system-level designs and control strategies.	L6
CO5	Use simulation and prototype testing to validate system performance and perform multi-objective optimization	L5
CO6	Incorporate manufacturability, cost, safety, reliability and environmental impact into design decisions and document design rationale.	L6

CO PO Mapping

Course Outcome	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	2	2			1				1		2	2	
CO2	3	3	2			3	2			1		1	3	
CO3	2	3	3	2	2					1	2	1	3	2
CO4	3	3	3		2				2			1	3	2
CO5	2	3	2		3				2	1		12	2	3
CO6	2	2	3	3		3	3	2		2	3	1	2	

Assessment	
CA-1 (a)	Subjective Test
CA-2 (b)	Assignment
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Systems Engineering & Requirements** Systems engineering lifecycle: concept, design, development, verification, validation, production, sustainment. Requirements engineering: stakeholder analysis, regulatory requirements (emissions, safety), functional & non-functional requirements. Use-cases, use of QFD (House of Quality) to map customer needs to engineering specs. System decomposition, interface definition, V-model for automotive systems.	6 Hrs.
Unit 2	**Vehicle/Product Architecture & Concept Design** Vehicle architectures: ICE, hybrid, BEV architectures; modular vs integrated designs. Function allocation across subsystems (power train, chassis, EE, thermal). Concept generation tools: morphological charts, TRIZ, brainstorming and concept screening. Concept evaluation: Pugh matrix, AHP, multi-criteria decision making.	6 Hrs.
Unit 3	**Subsystem Design: Power train, Chassis & Thermal** Power train design considerations for ICE/Hybrid/EV: performance, efficiency, packaging, gearboxes, transmission options. Chassis/suspension/steering design trade-offs: ride vs handling, kinematics and compliance. Vehicle thermal management (cooling, HVAC for occupant comfort and battery thermal management). Packaging, mass distribution, and center of gravity management.	6 Hrs.
Unit 4	**Electrical/Electronic Architecture & Controls** Automotive EE architecture: CAN, LIN, FlexRay, vehicle networks, zonal vs centralized ECUs. Sensors, actuators, wiring harness design considerations. Control system design basics: control loops for engine, transmission, braking (ABS/EBD), traction control, ADAS basics. Model-Based Design (MBD), rapid prototyping, hardware-in-the-loop (HIL) basics.	6 Hrs.
Unit 5	**Safety, Reliability, NVH & Regulations** Functional safety (ISO 26262) principles and safety lifecycle for automotive systems. Reliability prediction, FMEA/FMECA for subsystem design. Noise, vibration and harshness (NVH) considerations and mitigation strategies. Regulatory compliance: emissions, safety (crashworthiness basics), homologation considerations.	6 Hrs.
Unit 6	**Systems Validation, Optimization & Emerging Topics** Simulation workflows: multi-body dynamics, CFD for aero/thermal, battery and power train simulation, co-simulation strategies. Multi-objective optimization (Pareto, genetic algorithms) and trade-off curves. Prototyping, instrumenting tests, data acquisition, test planning and correlation between simulation and test. Emerging topics: electrification integration, vehicle software architecture, sustainability and LCA, connected/autonomous vehicle impacts on system design. Case studies (design of an EV power train module, brake-by-wire system, thermal management for battery pack etc.)	6 Hrs.

Sr. No	Text/Reference Books
	Textbooks
1	Wolfgang Endisch, "Automotive System Engineering", Springer — (good overview of systems engineering applied to vehicles).
2	N. K. Giri, "Automotive Mechanics", McGraw Hill
3	Rajesh Rajamani, "Vehicle Dynamics and Control", Springer — (for dynamics/control aspects).
4	Michael E. Mortenson, Geometric Modeling, 3rd Edition, Industrial Press, 2006.
Sr. No	**Reference Books**
1	Hans B. Pacejka, "Tire and Vehicle Dynamics", Butterworth-Heinemann.
2	Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", SAE /Society of Automotive Engineers.

3	Gillespie &Guzzella, "Modeling and Control of Engines and Drivetrains" (various authors/chapters in modern collections).
4	J. R. Webster, "Handbook of Automotive Engineering"

Web Resources	
1	**Fundamentals of Automotive Systems** By Prof. C. S. Shankar Ram (IIT Madras) https://nptel.ac.in/courses/107106088
2	**Design of Mechanical Transmission Systems** By Prof. Ramkumar P (IIT Madras) https://nptel.ac.in/courses/112106424
3	**Ergonomics in Automotive Design** By Prof. V. D. Bhise (IIT Bombay) https://nptel.ac.in/courses/107106088
4	**Smart Materials and Intelligent System Design** By Prof. V. D. Bhise (IIT Bombay) https://nptel.ac.in/courses/107106088

Course Title: Automated Guided Vehicle **Course Code: PA252110**	**Course Category:** PE IV	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs./ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks

Course Prerequisite: Fundamentals of Robotics & Control Systems, Sensors and Actuators, Mobile Robotics / Path Planning

Course Description: This elective course introduces theory, design, control, and applications of Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) in industrial and service environments. The course covers localization, mapping, navigation, motion planning, perception, sensor integration, fleet management, communication, safety, and human–robot interaction. Students will analyse AGV architectures, select suitable sensors/actuators, design navigation stacks, and study real-world deployment challenges such as obstacle avoidance, traffic management, task scheduling, and battery/energy considerations.

Course Objectives:

1. Understand AGV system architectures, classifications, components, and industrial use-cases.
2. Model kinematics and dynamics of mobile platforms and design motion controllers.
3. Implement localization and mapping techniques for indoor/outdoor navigation.
4. Develop motion planning and obstacle avoidance strategies for dynamic environments.
5. Design sensor fusion and perception pipelines for AGV operation.
6. Explain fleet coordination, task allocation, communication protocols and safety standards for AGV deployment.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall and describe the historical evolution, classifications, architectures, system components, and industrial applications of AGVs/AMRs, including basic economic considerations and selection criteria.	L1
CO2	Explain and interpret kinematic structures, non-holonomic constraints, sensor characteristics, error sources, and safety standards relevant to AGV/AMR operation and deployment.	L2
CO3	Apply kinematic models, motion control algorithms (PID, Pure Pursuit, Stanley), sensor calibration methods, and basic localization techniques to solve AGV navigation and control problems.	L3
CO4	Analyze dynamic behaviour, actuator sizing, sensor fusion methods (Kalman filter, EKF/UKF, particle filters), and motion planning algorithms to evaluate AGV performance under constraints and uncertainties.	L6
CO5	Evaluate and compare global and local path planning strategies, fleet management architectures, task allocation methods, and safety risk mitigation techniques to justify suitable solutions for real-world AGV	L5
CO6	Design and integrate a complete AGV/AMR system incorporating perception, localization, motion planning, control, communication middleware, fleet coordination, and safety compliance for dynamic industrial environments.	L6

CO PO and PSOs Mapping

Course Outcome	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO 8**	**PO 9**	**PO 10**	**PO1 1**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	2		1	2				1		2			
CO2	3	2	2	1	2				1		2			
CO3	3	3	3	2	2				1		2			
CO4	3	3	3	3	2	1	1	1	1	1	2	1		
CO5	3	2	3	3	3	1	1		1	1	2	1		

CO6	2	1	2	1	2	3	3	3	1	2	2	1		

Assessment	
CA-1 (a)	Subjective Test
CA-2 (b)	Assignment
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction & AGV Architectures** Historical evolution and industrial motivation for AGVs/AMRs. Classification: fixed-path AGV, free-ranging AGV, automated guided carts, towing, unit load, fork-equipped, hybrid systems, service robots. System components: drive systems, guidance systems, power systems, communication, safety devices. Industrial applications: warehousing, assembly, material handling, hospitals, airports, last-mile delivery cases. Economic analysis and selection criteria.	6 Hrs.
Unit 2	**Kinematics, Dynamics & Motion Control** Kinematic models of mobile robots: differential drive, skid-steer, omnidirectional (Mecanum, Omni-wheels), Ackermann steering. Non-holonomic constraints and controllability. Trajectory generation, path following controllers (PID, pure pursuit, Stanley), feedback linearization. Dynamics basics, actuator sizing, motor selection, velocity/torque control.	6 Hrs.
Unit 3	**Sensing & Perception** Sensors: encoders, IMUs, wheel odometry, LiDAR, ultrasonic, RGB/RGB-D cameras, depth sensors, RFID, UWB. Sensor characteristics, error models and calibration. Feature extraction, landmark detection, visual odometry overview. Sensor fusion basics: complementary filters, Kalman filter, EKF/UKF, particle filters.	6 Hrs.
Unit 4	**Localization & Mapping** Global planning: grid-based (A*), heuristic search, D* / D* Lite, PRM, RRT, optimal variants (RRT*, PRM*). Local planning: Dynamic Window Approach (DWA), Artificial Potential Fields, Velocity Obstacles, Model Predictive Control for obstacle avoidance. Motion planning under differential constraints and kinodynamic planning. Real-time planning for dynamic environments.	6 Hrs.
Unit 5	**Path Planning & Obstacle Avoidance:** Global planning: grid-based (A*), heuristic search, D* / D* Lite, PRM, RRT, optimal variants (RRT*, PRM*). Local planning: Dynamic Window Approach (DWA), Artificial Potential Fields, Velocity Obstacles, Model Predictive Control for obstacle avoidance. Motion planning under differential constraints and kinodynamic planning. Real-time planning for dynamic environments.	6 Hrs.
Unit 6	**Fleet Management, Middleware, Safety & Deployment** Fleet architectures: centralized, decentralized, distributed approaches. Task allocation and scheduling: auction-based methods, market-based allocation, task sequencing, deadlock avoidance. Communication technologies (WiFi, ROS, DDS, MQTT, OPC-UA) and middleware (ROS/ROS2 architecture, topics, services, action servers). Safety standards (ISO 3691-4 for industrial trucks/AGV safety, ISO 13849 basics), emergency stop, FMEA and risk assessment.	6 Hrs.

Sr. No	Text/Reference Books
	Textbooks
1	Roland Siegwart, Illah R. Nourbakhsh, DavideScaramuzza — Introduction to Autonomous Mobile Robots, MIT Press. (Good for fundamentals; kinematics, perception, planning.)
2	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo — Robotics: Modelling, Planning and Control, Springer. (Kinematics, control.)
3	Sebastian Thrun, Wolfram Burgard, Dieter Fox — Probabilistic Robotics, MIT Press. (Localization, mapping, filters.)
4	H. Hu, Yinong Wang — Automated Guided Vehicle Systems: A Primer with Practical Applications (or similar industry-focused AGV references).

Sr. No	Reference Books
1	Lawrence D. Erceg, et al. — Mobile Robots: Inspiration to Implementation.
2	Roland Siegwart & Illah Nourbakhsh — Introduction to Autonomous Mobile Robots (alternate edition).
3	ISO 3691-4 — Industrial trucks – Safety requirements – Driverless industrial trucks and their systems (use for safety modules).
4	IEEE and ICRA/ICRA conference papers on AGV fleet management, SLAM, and multi-robot coordination.

Web Resources	
1	**Robotics: Advanced Concepts & Analysis** — Prof. Ashitava Ghosal (IISc Bangalore) https://archive.nptel.ac.in/content/storage2/courses/112108093/module9/lecture.pdf
2	**Introduction to Industrial Automation and Control** — Prof. S. K. Saha (IIT Kharagpur) https://archive.nptel.ac.in/content/storage2/courses/108105063/pdf/L-01%28SM%29%28IA%26C%29%20%28%28EE%29NPTEL%29.pdf
3	**Products and Systems in Manufacturing** — Prof. S. K. Saha (IIT Kharagpur) https://archive.nptel.ac.in/content/storage2/courses/112103174/module1/lec2/3.html
4	**Creative Engineering Design** — Prof. S. K. Saha (IIT Kharagpur) https://archive.nptel.ac.in/content/storage2/courses/107108010/mod06/lec06.pdf

Course Title: Computational Fluid Dynamics **Course Code: PA252111**	**Course Category:** PE IV	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs./ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks

Course Prerequisite: Undergraduate course in Fluid Mechanics and Heat Transfer, Basic Numerical Methods / Computational Methods, Elementary programming experience (MATLAB / Python / C++)

Course Description: This elective introduces advanced concepts and numerical methods in Computational Fluid Dynamics (CFD) with an emphasis on automotive applications (external aerodynamics, internal flows in engines and HVAC ducts, multiphase flows, combustion modeling, and cooling). The course covers governing equations, Discretization techniques, turbulence modeling, mesh generation and quality, solution algorithms, verification & validation, and post-processing. Practical sessions include hands-on use of commercial/open-source CFD tools, setting up automotive-relevant cases, and interpreting results for design decisions.

Course Objectives:

1. Introduce the mathematical formulation of fluid flow and heat transfer problems relevant to automotive engineering.
2. Teach numerical discretization methods (finite difference, finite volume, finite element) and their implementation for CFD.
3. Develop competency in turbulence modeling, boundary layer treatment, and multiphase/combustion modeling for automotive applications.
4. Train students to set up, run, verify, validate and interpret CFD simulations using standard tools.
5. Build capability to use CFD results for engineering decisions in vehicle aerodynamics, engine flows, thermal management, and cabin comfort.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Derive and interpret the Navier–Stokes equations and associated conservation laws for automotive flows.	L3
CO2	Select and apply appropriate numerical discretization and solution algorithms for laminar and turbulent flows.	L1, L3
CO3	Generate and evaluate structured and unstructured meshes; assess mesh quality and its impact on solution accuracy and convergence.	L4
CO4	Choose and apply turbulence models and multiphase/combustion models suitable for specific automotive problems.	L3, L6
CO5	Perform verification, validation, and sensitivity studies and critically interpret CFD results against experiments or analytical solutions.	L5
CO6	Use commercial/open-source CFD software to model realistic automotive cases (external aerodynamics, internal engine/cooling flows) and present engineering recommendations.	L6

CO PO Mapping

Course Outcome	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	3	1	2	1							2	3	1
CO2	3	3	2	2	3							2	2	3
CO3	2	3	2	3	3							2	2	3
CO4	2	3	3	2	3		1					2	3	3
CO5	2	3	2	3	2					1		3	2	3
CO6	2	2	3	2	3	1	1		2	3	1	3	3	3

Assessment	
CA-1 (a)	Subjective Test
CA-2 (b)	Assignment
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Mathematical Foundations & Governing Equations** Conservation laws: continuity, momentum, energy (integro-differential form) Compressible and incompressible flow formulations, Boundary conditions for internal/external automotive flows, Dimensional analysis, non-dimensional numbers (Re, Ma, Pr, etc.) and scaling for automotive problems	6 Hrs.
Unit 2	**Numerical Methods & Discretization** Introduction to discretization approaches: finite difference (FDM), finite volume (FVM), finite element (FEM), Conservative discretization principles; staggered vs collocated grids, Spatial discretization schemes: upwind, central, QUICK, higher-order schemes, Temporal discretization: explicit, implicit, Crank–Nicolson, Stability, consistency, convergence; CFL condition	6 Hrs.
Unit 3	**Pressure–Velocity Coupling, Solvers & Linear Algebra** Pressure–velocity coupling techniques: SIMPLE, SIMPLER, PISO, fractional-step methods, Solvers for linear systems: direct and iterative solvers, preconditioning, convergence acceleration, Multigrid methods and parallelization concepts, Boundary layer modeling and near-wall treatment (wall functions vs near-wall resolving)	6 Hrs.
Unit 4	**Turbulence Modeling & Combustion** RANS: k–ε, k–ω, SST and variants; limitations, Scale-resolving simulations: LES, DES (fundamentals and costs), Combustion modeling basics for engine flows: flamelet models, EDC, PDF methods (overview), Turbulence-chemistry interaction and modeling choices for automotive combustion.	6 Hrs.
Unit 5	**Mesh Generation, Quality, & Multiphase/Multi-physics** Structured, unstructured, hybrid meshes; grid generation techniques for automotive geometries, Mesh quality metrics, adaptive mesh refinement (AMR), boundary layer mesh, Multiphase flows: VOF, Euler–Lagrange approaches; spray modeling basics (fuel injector sprays), Conjugate heat transfer (CHT), fluid–structure interaction (basic introduction)	6 Hrs.
Unit 6	**Verification, Validation, Post-processing & Automotive Applications:** Verification vs validation; grid convergence studies (GCI), error estimation, Uncertainty quantification and sensitivity analysis (overview), Post-processing: flow visualization, aerodynamic coefficients, forces/moments, heat transfer rates, Automotive case studies: external aerodynamics (Cd, downforce), engine intake/exhaust flows, turbocharger flows, thermal management (radiator, battery cooling), cabin HVAC.	6 Hrs.

Sr. No	Text/Reference Books
	Textbooks
1	J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, 2nd ed., McGraw-Hill
2	H. K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd ed., Pearson.
Sr. No	**Reference Books**
1	M. Griebel, T. Dornseifer, T. Neunhoeffer, Numerical Simulation in Fluid Dynamics — A Practical Introduction, SIAM.
2	C. Hirsch, Numerical Computation of Internal and External Flows, Volumes 1 & 2, Wiley.
3	T. J. Chung, Computational Fluid Dynamics, Cambridge University Press.

Web Resources	
1	Computational Fluid Dynamics Instructor: Prof. SumanChakraborty (IIT Kharagpur) Link: https://nptel.ac.in/courses/112105045
2	Computational Fluid Dynamics Instructor: Dr. K. M. Singh (IIT Roorkee) Link: https://nptel.ac.in/courses/112107079
3	Computational Fluid Dynamics for Incompressible Flows Instructor: Prof. AmareshDalal (IIT Guwahati) Link: https://nptel.ac.in/courses/112103289
4	Applied Computational Fluid Dynamics Instructor: Prof. Rajesh Ranjan (IIT Kanpur) Link: https://onlinecourses.nptel.ac.in/noc24_ae23/preview
5	Foundation of Computational Fluid Dynamics Instructor: Prof. Vengadesan (IIT Madras) Link: https://onlinecourses.nptel.ac.in/noc20_me64/preview

Course Title: Automotive Testing and Certification **Course Code: PA252112**	**Course Category: PEC**	
Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester-II)	ESE	60 Marks
Course Prerequisite: Automotive Engineering, Engine Technology, Automotive Safety.		

Course Description:

This course introduces students to the fundamentals of vehicle testing and homologation with emphasis on regulatory requirements and approval procedures. It covers vehicle classification, type approval schemes, and global regulations such as AIS, CMVR, ECE, and FMVSS. Students will study static, dynamic, component, lighting, and safety testing methods along with emission and crash standards. The course also explores certification processes for electric and hybrid vehicles under recent regulatory frameworks.

Course Objectives:

1. To familiarize students with the fundamentals of vehicle classification, type approval, and homologation processes.
2. To provide knowledge of national and international automotive regulations (AIS, CMVR, ECE, FMVSS) governing vehicle safety, emissions, and performance.
3. To explain the principles and procedures of static, dynamic, component, and lighting tests carried out during vehicle certification.
4. To create awareness of recent developments in electric and hybrid vehicle testing and their certification requirements.
5. To develop an understanding of conformity of production, export homologation, and regulatory compliance in the automotive industry.

Course Outcomes:

Cos	After completion of the course: Student should be able to	Bloom's Level
CO1	Recall the classification of vehicles, homologation types, and key regulatory frameworks such as AIS, CMVR, ECE, and FMVSS.	L1
CO2	Explain the purpose, principles, and procedures of static, dynamic, component, and lighting tests carried out during vehicle certification.	L2
CO3	Apply regulatory guidelines to identify the testing requirements for different categories of vehicles, including electric and hybrid vehicles.	L3
CO4	Analyze the conformity of production and type approval schemes to assess compliance with national and international standards.	L4
CO5	Evaluate recent advancements in vehicle testing and homologation processes to understand their impact on safety, emissions, and global automotive trade.	L5

CO-PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / Assignment.
CA-2 (b)	Assignment / Presentation/ Case Study
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction of Certification and Homologation:** Specification & Classification of Vehicles- M, N, O layout, Homologation & Types of homologation, Regulations overview- EEC, ECE, FMVSS, AIS,CMVR, Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks.	6 Hrs
Unit 2	**Static Automotive Test:** Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Wightman, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls For Vehicle, Angle & Dimensions Measurement of Vehicle.	6Hrs
Unit 3	**Dynamic Automotive Test:** Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test. Engine power test, Indian driving cycle, Vehicle mass emission, Evaporative emission, Vehicle Crash Testing.	6Hrs
Unit 4	**Automotive Component Testing:** Wind screen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre& Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test, Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System.	6 Hrs
Unit 5	**Automotive Lighting Testing:** Installation requirement for lighting, signaling& reflective devices Installation, Conspicuity & Reflective Marking, Photometry Test: Performance requirement for lighting, signaling and reflective devices - Head lamp, Front lamp, direction indicator lamp, signaling lamp and Warning triangles.	6Hrs
Unit 6	**Recent Technology Testing:** Electric Vehicle Certification and Homologation- AIS, ECE regulations. Hybrid Vehicle Certification and Homologation- AIS, ECE regulations.	6 Hrs

Text/Reference Books	
Text Books	
1.	G. P. Geetha krishnan, Vehicle Regulations and Homologation, Notion Press Publisher, 2021.
2	Dr. N. K. Giri, Automotive Vehicles: Testing and Homologation, Khanna Publisher.
Reference Books	
1	Robert Bosch GmbH, Automotive Handbook, 11th Edition, 2022.

Web Resources	
1.	Indian Standards (AIS and CMVR). (https://morth.nic.in/automotive-industry-standards-ais)
2.	Automotive Research Association of India. (https://araiindia.com)

Course Title: Research Methodology **Course Code: PG252601**	**Course Category: EL**

Teaching Scheme	**Examination Scheme**	
Lectures: 03 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 03	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks

Course Prerequisite: Basic knowledge of engineering fundamentals, Familiarity with undergraduate-level mathematics and statistics, Ability to use computers and standard engineering software tools

Course Description:

This course introduces postgraduate engineering students to the principles, processes, and practices of research methodology. It emphasizes problem identification, literature review, research design, data collection, analysis, and interpretation. The course also covers ethical practices, mathematical modeling, computational tools, and scientific communication through thesis, research papers, and presentations. It aims to equip students with essential skills to undertake independent research projects and contribute effectively to the advancement of science and technology.

Course Objectives:

1. To provide a clear understanding of the fundamentals and process of research in engineering.
2. To develop the ability to identify research problems through literature review and formulate hypotheses.
3. To impart knowledge of research ethics, integrity, and professional responsibility.
4. To familiarize students with research design, data collection, analysis, and interpretation techniques.
5. To introduce mathematical modelling and computational tools relevant to engineering research.
6. To develop effective academic writing and presentation skills for disseminating research outcomes.

Course Outcomes:

Cos	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Recall the meaning, objectives, and types of research, along with problem identification and hypothesis formulation.	L1
CO2	Demonstrate understanding of ethical issues, research integrity, plagiarism, and intellectual property rights.	L2
CO3	Design appropriate research methodologies, select data collection methods, and apply suitable statistical techniques for analysis.	L3
CO4	Develop and validate mathematical and computational models for engineering applications using appropriate tools/software.	L4
CO5	Write and present research outputs in the form of proposals, reports, papers, and presentations adhering to academic standards.	L5

CO PO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open book test / Assignment.
CA-2 (b)	Assignment / Presentation/ Case Study
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Introduction to 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,	6 Hrs
Unit 2	**Research Ethics:** 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	6Hrs
Unit 3	**Research Design, Experimentation, and Analysis And Data Analysis and Interpretation:** 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	6 Hrs
Unit 4	**Mathematical Modeling in Engineering Research, Use of Computer Technology and Software:** 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, Solid Works, and other CAD tools, Data analysis software: Usage and applications, Big data and machine learning in engineering research	6 Hrs
Unit 5	**Writing and Presenting Research: 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., End Note, 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	6Hrs
Unit 6	**Case Studies and Applications:** Case studies of successful engineering research, Application of research methodologies to real-life projects, Problem-solving through interdisciplinary approaches, Integration of ethical, technical, and methodological aspects, Emerging trends in engineering research.	6 Hrs

Text/Reference Books	
Text Books	
1	C. R. Kothari, Research Methodology, New Age Publishers.
2	Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners

3	Herman Tang, Engineering Research: Design, Methods, and Analysis
4	Douglas C. Montgomery, Design and Analysis of Experiments
5	C. Neal Stewart Jr., Research Ethics for Scientists: A Companion for Students
Reference Books	
1	Cooper, D.R. & Schindler, P.S. – Business Research Methods, McGraw Hill.
2	Montgomery, D.C. – Design and Analysis of Experiments, Wiley.
3	Krishnaswamy, K.N., Sivakumar, A.I., Mathirajan, M. – Management Research Methodology, Pearson.
4	Deborah Rumsey – Statistics for Dummies, Wiley.

Web Resources	
1	MIT OpenCourseWare: Research Methods (https://ocw.mit.edu)
2	NCBI – PubMed Central (https://www.ncbi.nlm.nih.gov/pmc/)
3	https://researcheracademy.elsevier.com/
4	https://link.springer.com/

Course Title: Interdisciplinary Perspective on Indian Science and Technology **Course Code: PG252501** **Course Category: IKS**		
Teaching Scheme	**Examination Scheme**	
Lectures: 02 hrs/ week	CA-1	10 Marks
Tutorial: -----	CA-2	10 Marks
Credits: 02	MSE	20 Marks
Semester: First Year (Semester II)	ESE	60 Marks
Course Prerequisite: None		

Course Description:

The course Scientific Heritage of India introduces students to India's rich contributions in mathematics, astronomy, architecture, metallurgy, textiles, and agriculture. It emphasizes the scientific principles embedded in traditional practices, tracing their historical development and global impact. Students will explore how ancient Indian innovations such as the number system, astronomical instruments, town planning, metallurgy, and sustainable farming shaped modern science and engineering. The course bridges theoretical understanding with practical relevance, enabling appreciation of indigenous knowledge systems and their applications in contemporary contexts.

Course Objectives:

1. To understand the foundational concepts and necessity of the Indian Knowledge System.
2. To identify key historical contributions of Indian scholars in mathematics, astronomy, architecture, metallurgy, textiles, and agriculture.
3. To interpret the scientific principles and techniques underlying traditional Indian practices.
4. To analyze the relevance of IKS in modern scientific and technological contexts.
5. To appreciate the global influence and sustainability of Indian innovations throughout history.

Course Outcomes:

COs	**After completion of the course, students should be able to**	**Bloom's Level**
CO1	Recall key concepts, terminologies, historical developments, and contributions in Indian Mathematics, Astronomy, Architecture, Metallurgy, Textiles, and Agriculture.	L1
CO2	Explain the principles, methods, and scientific basis of Indian Knowledge Systems in various domains such as mathematics, astronomy, architecture, metallurgy, textiles, and agriculture.	L2
CO3	Use traditional Indian scientific and technological methods to address contemporary or theoretical problems in relevant fields.	L3
CO4	Examine the relevance, strengths, and limitations of Indian Knowledge Systems in addressing contemporary scientific, environmental, technological, and societal challenges.	L4

CO-PO-PSO Mapping

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

Assessment	
CA-1 (a)	Subjective Test / Open-book test / etc.
CA-2 (b)	Model Making / Assignment / Presentation /etc.
MSE (c)	Mid Sem Examination

Course Contents		
Unit 1	**Indian Mathematics** Necessity of Indian Knowledge System, Defining Indian Knowledge System, Contributions of Indian Mathematicians, Historical Evidence and features of Indian Numerical Number System, The Idea of Zero and Infinity, Decimal System, Representation of Large Numbers, Global Spread and Adoption of Indian Numerical, Arithmetic (Square of a Number, Square Root, Series and Propagation), Geometry (Simple Constructions from Sulba-Sutras,e.g, Right Angle Triangle, The Value of Pi), Trigonometry and Algebra in IKS, Modern Indian Contributions to Mathematics	4 Hrs
Unit 2	**Indian Astronomy** Historical Development of Indian Astronomy, Astronomy for Timekeeping, Solar and Lunar Motions, The Celestial Coordinate System, Various Regional Indian Calendar Systems, Planetary Model of Aryabhata and Nilakantha, Astronomical Instruments, Various Royal Endeavors for Astronomy (e.g., Jaisingh'sJantarMantar), Modern Indian Contributions to Astronomy	4 Hrs
Unit 3	**Indian Architecture and Town Planning** Sthapatya-Veda and Vastu-Shastra, Historical Features of Indian Town Planning, Water Management and Drainage Systems, Town Town Planning of Harappan Cities, Temple Architecture, Features and Examples of Cave, Rock Cut, Nagara, Dravida, Kalinga, Vesara, Deccan, Rajput, Mughal, Indo-Saracenic Architecture Styles, Modern Indian Contributions to Architecture and Town Planning	4 Hrs
Unit 4	**Indian Metallurgy** Ancient Mining and Ore Extraction Technologies, Mining and Manufacture of Zinc, Copper and its Alloys, Silver, Gold, Mercury and Lead, Iron Extraction from Biotite, Steel Manufacturing, Global Influence of Wootz Steel, Wax Casting, Modern Indian Contributions to Metallurgy	4 Hrs
Unit 5	**Indian Textile** Textile Traditions in Ancient India, The Variety and Diversity of Indian Textiles, Types of Fabrics and Materials, Cotton and Silk, Weaving Techniques and Looms, Dyeing Process and Natural Colors, Major Textile Centers, Significance of Indian Textile in Historical Global Trade, Fall of Indian Textile in Colonial Era, Modern Indian Contributions to Textile	4 Hrs
Unit 6	**Indian Agriculture** Importance of Agriculture in Ancient India, Traditional Crops (Grains, Fruits, Vegetables Spices), Significance of Indian Agricultural Products in Historical Global Trade, Significance of Agriculture and Irrigation for the Indian Kings, The Ery System of South India, Traditional Farming Techniques (Land Preparation, Sowing Techniques, Weeding and Pest Management, Harvesting and Storage), Irrigation Techniques and Rainwater Harvesting, Modern Indian Contributions to Agriculture	4 Hrs

Text/Reference Books	
Text/ Books	
1.	D. M. Bose, S. N. Sen and B. V. Subbarayappa, Eds., A Concise History of Science in India, 2nd Ed., Universities Press, Hyderabad, 2010.
2	B. Mahadevan, Nagendra Pavana, Vinayak Rajat Bhat, Introduction to Indian Knowledge System: Concepts and Applications, PHI Learning, 2022
3	G. G. Joseph, Indian Mathematics Engaging the World from Ancient to Modern Times, World Scientific, London, 2016
4	History of Astronomy: A Handbook, Edited by K. Rama subramanian, Aniket Sule, and Mayank Vahia, SandHI, IIT Bombay, and T.I.F.R. Mumbai, 2016.
	Reference Books
1	Kapil Kapoor, Awadhesh Kumar Singh, Indian Knowledge Systems, D.K. Print World Ltd; First Edition (15 October 2005)
2	Bhag Chand Chauhan, IKS: The Knowledge system of Bharata, Garuda Prakashan (13 March 2023)
3	History of Science in India Volume-1, Part-I, Part-II, Volume VIII, by SibajiRaha, et al. National Academy of Sciences, India and The Ramkrishna Mission Institute of Culture, Kolkata (2014).
4	Science in India: A Historical Perspective by B V Subbarayappa, Rupa& Co (2013)

5	Christopher Tadgell, History of Architecture in India, Architecture Design and Technology Press (1990)
6	BindiaThapar, Introduction to Indian Architecture, Periplus Asian Architecture Series

Web Resources	
1	**History of Indian Science and Technology** — Instructor(s) not explicitly listed in search snippet Course Link Swayam
2	**Science, Technology and Society** — Prof. SambitMallick, IIT Guwahati Course Link NPTEL Online Courses
3	**Introduction to Ancient Indian Technology** — Prof. D. P. Mishra, IIT Kanpur Course Link

Course Title: Mini project **Course Code:** PA252602		**Course Category:** EL
Teaching Scheme	**Examination Scheme (As Applicable)**	
Practical's/Sessions: 02 Hours/Week	CA-I	15 Marks
	CA-II	15 Marks
Semester: First Year (Semester-II)	ESE	20 Marks

Course Prerequisite:

- Basic understanding of core subjects in specialization, Ability access, and interpret scientific literature.
- Exposure to technical report writing and presentation.

Course Description:

The Mini Project course provides students with an opportunity to apply theoretical knowledge gained during coursework to a small-scale practical problem in Mechanical Engineering. It enables students to experience the process of identifying a problem, reviewing literature, formulating objectives, and developing solutions using experimental, analytical, or simulation-based approaches. The course emphasizes independent learning, teamwork, critical thinking, innovation, and technical communication.

Course Objectives:

1. Develop the ability to identify, analyze, and solve engineering problems using modern tools and techniques.
2. Encourage creativity, innovation, and research aptitude in addressing mechanical engineering challenges.
3. Provide hands-on exposure to design, modeling, analysis, and/or experimental work on a defined problem.
4. Strengthen teamwork, project management, and professional ethics in executing engineering tasks.
5. Enhance technical writing and oral presentation skills through project documentation and seminars.

Course Outcomes:

COs	**After completion of the course: Student should be able to**	**Bloom's Level**
CO1	Identify and define a relevant problem in the domain of Mechanical Engineering.	L4
CO2	Conduct literature survey and establish research/technical objectives.	L5
CO3	Apply appropriate engineering methods, tools, and techniques to develop and implement solutions.	L6
CO4	Work independently or in a team, demonstrating project management, ethical practices, and leadership.	L3
CO5	Demonstrate the ability to answer questions, engage in discussions, and defend ideas confidently.	L6

CO-PO Mapping

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

Course Contents

The Mini project shall consist of identification, analysis, finding solutions and execution of live Mechanical Engineering and Managerial problems. It is also aimed at enhancing the capabilities of the students. Individual students are required to choose a topic of 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/Automobile 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.

Assessment

Mini Project will have internal marks 30 and Semester-end examination marks 20.

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. The committee will evaluate the students individually and marks shall be awarded as follows.

CA-I (a)	Review-I: 15 Marks (Concept/knowledge in the topic = 10 marks, Literature-05 marks)
CA-II (b)	Review-II: 15 Marks (Report writing & Presentation =15 Marks)
Practical/ viva voce (c)	20 Marks (Individual evaluation through viva voce / test (20 marks)
Total (d)	50 Marks