SEMESTER II

Sr No.	Course Category	Course Code	Course Title	Hours Per Week			Credits	Maximum Marks			Min Passing marks	No. of Hrs for ESE
				L	T	P		Continual Assessment	End Sem Examination	Total		
1.	PCC	26AT201T	Finite Element Methods and Analysis	4	-	-	4	40	60	100	50	3
2.	PCC	26AT201P	Finite Element Methods and Analysis Lab	-	-	2	1	25	25	50	25	-
3.	PCC	26AT202T	Fuel Cell Technology	4	-	-	4	40	60	100	50	3
4.	PCC	26AT203T	Electric Vehicles	4	-	-	4	40	60	100	50	3
5.	PCC	26AT203P	Electric Vehicles Lab	-	-	2	1	25	25	50	25	-
6.	PEC	26AT204T	Program Elective – III	4	-	-	4	40	60	100	50	3
7.	PEC	26AT205T	Program Elective – IV	4	-	-	4	40	60	100	50	3
8.	CEP	26AT206P	IPR/ Quantitative Methods/ Design of Experiments	-	-	2	1	50	-	50	25	-
Total				**20**	**0**	**06**	**23**	**300**	**350**	**650**	-	-

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Basket for Program Elective – III Courses

II	PEC	26AT204T(i)	Automotive Safety Systems	4
II	PEC	26AT204T(ii)	Automotive Testing and Validation	4
II	PEC	26AT204T(iii)	Data Science and Analytics	4

Basket for Program Elective – IV Courses

II	PEC	26AT205T(i)	Design of Battery Pack and Thermal Modelling	4
II	PEC	26AT205T(ii)	Automotive Tribology and Maintenance	4
II	PEC	26AT205T(iii)	Vehicle body Engineering	4

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT201T	Finite Element Methods and Analysis	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To impart a solid understanding of the fundamentals of the finite element method, focusing on its theory, assumptions, and modeling challenges. 2. To develop skills in applying finite element software for modeling and analyzing stresses, strains, and deformations in machine and structural components. 3. To enable students to evaluate natural frequencies and modal shapes through the finite element method for effective design and analysis. 4. To provide hands-on experience in solving real-world engineering problems using finite element tools, emphasizing practical applications and problem-solving techniques.	1. Identify the application of fundamentals of solid mechanics for evaluation of structural problems for evaluation of Point load, body force, traction and torsional loads. 2. Study the application and formulation of the basic finite elements for static and truss, beam and bars subjected to plane stress and plane strain behavior. 3. Formulate mathematical models for the solution of common engineering problems using finite element methods i.e, formulation of simple & complex problems using finite elements and to develop the ability to generate the governing finite element equations for systems regulated by partial differential equations. 4. Identify the significance and difference between the formulation and application of thermal engineering problems using1D & 2D finite elements. 5. Formulate dynamic problems to study and evaluate structural response under free vibration.

Unit I	**[12 Hrs]**
Introduction to FEM: basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, Coordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain-displacement relations. Point load, torsion problem formulation.	
Unit II	**[12 Hrs]**
1-D STRUCTURAL PROBLEMS: Axial bar element–stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems. Plane Trusses and Axi-symmetric Truss elements, and problems Beam bending problem, Hermite shape functions–stiffness matrix– Load vector.	
Unit III	**[12 Hrs]**
2-D PROBLEMS: CST, force terms, Stiffness matrix and load vectors, boundary conditions, Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements.	
Unit IV	**[12 Hrs]**
SCALAR FIELD PROBLEMS:1-D Heat conduction-Slabs–fins, Coefficient of thermal expansion.	
Unit V	**[12 Hrs]]**
Frequency Response: Dynamic considerations, Dynamic equations–consistent mass matrix– Eigen Values, Eigen vector, natural frequencies–mode shapes–modal analysis.	

Text Books

S.N	Title	Authors	Edition	Publisher
1	Introduction to Finite Elements in Engineering	Chandrupatla T. R. and Belegunda A. D	2015	Prentice Hall.
2	First Course in the Finite Element Method	Daryl Logan	2012	Cengage Learning

Reference Books

S.N	Title	Authors	Edition	Publisher
1	Finite Element Procedures	Bathe K. J	1996	Prentice-Hall of India
2	Finite Element Analysis, Theory, and Practice	Fagan M. J.	1996	Pearson Education Limited

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT201P	Finite Element Methods and Analysis Lab	-	-	2	1	25	25	50

Course Objectives	Course Outcomes
1.To teach the fundamentals of finite element method with emphasize on the underlying theory, assumption, and modeling issues. 2.To provide hands-on experience for using finite element software for modeling & analyzing stresses, strains, deformations, natural frequencies, modal shapes, etc. for machine/structural components. 3.To enable understanding of design evolution cycle through process of design validation	1. Model finite element problems using commercial software and understand the fundamental use of finite element preprocessor, solver and post-processor. 2. Demonstrate the ability to evaluate and interpret Finite Element Analysis Results for the design and evaluation of 1D and 2D finite element formulations. 3. Understand the Finite Element Modeling aspects of the Frequency response problem for solving engineering design problems.

Minimum 8 experiments to be performed

Expt. No.	Title of the experiment
1	Static structural analysis of Axially loaded bar with 1-D finite elements using standard FEA package.
2	Static structural analysis of bar under the influence of self-weight using 1-D finite elements using standard FEA package.
3	Static structural analysis of bar under applied torque using 1-D finite elements using standard FEA package.
4	Static structural analysis of 1D truss using standard FEA package.
5	Static structural analysis with 2-D Plane stress element using standard FEA package.
6	Static structural analysis with 2-D Plane strain element using standard FEA package.
7	Static structural analysis of a beam under transverse loading using standard FEA package.
8	Dynamic structural analysis to determine natural frequency and mode shapes, using standard FEA package.
9	Thermal analysis to estimate nodal temperatures using standard FEApackage.

Text Books

S.N	Title	Authors	Edition	Publisher
1	Introduction to Finite Elements in Engineering	Chandrupatla T. R. and Belegunda A. D	2015	Prentice Hall.
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2	Finite Element Analysis, Theory, and Practice	Fagan M. J.	1996	Pearson Education Limited

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT202T	Fuel Cell Technology	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To teach the fundamental principles and operation of fuel cells. 2. Explore various types of fuel cells and their applications. 3. Analyze the materials and components used in fuel cells. 4. Examine the integration of fuel cells into automotive systems. 5. Evaluate the challenges and future prospects of fuel cell technology.	1. Explain the working principles of different fuel cells. 2. Identify suitable materials and components for fuel cell construction. 3. Assess the performance and efficiency of fuel cells in automotive applications. 4. Integrate fuel cell systems into vehicles considering design and operational aspects. 5. Critically analyze the environmental and economic impacts of fuel cell technology.

Unit I	[12 Hrs]
Introduction to Fuel Cells : Fundamentals of electrochemical energy conversion. Historical development and evolution of fuel cells.Comparison with other energy conversion devices.	
Unit II	**[12 Hrs]**
Types of Fuel Cells Proton Exchange Membrane Fuel Cells (PEMFC).Solid Oxide Fuel Cells (SOFC).Molten Carbonate Fuel Cells (MCFC).Alkaline Fuel Cells (AFC).Phosphoric Acid Fuel Cells (PAFC).Applications and suitability of each type..	
Unit III	**[12 Hrs]**
Fuel Cell Components and Materials : Electrodes: Catalysts and supports.Electrolytes: Membranes and ceramics. Bipolar plates: Materials and design considerations.Manufacturing processes and material selection criteria.	
Unit IV	**[12 Hrs]**
Fuel Cell Integration in Vehicles : System architecture and design considerations.Hydrogen storage and fueling infrastructure.Powertrain integration and hybridization.Safety standards and regulatory aspects.	
Unit V	**[12 Hrs]**
Challenges and Future Trends : Durability and reliability issues.Cost reduction strategies and economic viability. Environmental impact and sustainability.Advancements in research and potential breakthroughs.	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Fuel Cell Systems Explained	Larminie, J., & Dicks, A	2000	Wiley–Blackwell
2.	Fuel Cell Fundamentals	O'Hayre, R., Cha, S.-W., Colella, W., & Prinz, F.B.	3rd	Wiley.

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	"Fuel Cell Engines	Mench, M.M.	2008	John Wiley & Sons
2,	PEM Fuel Cells: Theory and Practice	Barbir, F.	2nd	Academic Press Inc

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SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT203T	Electric Vehicles	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. Explain electric, hybrid electric and plug-in hybrid electric vehicle (PH EV), their architecture,- technologies and fundamentals. 2. Explain the design, component sizing of the power electronics converters and various electric drives suitable for hybrid electric vehicles. 3. Discuss different energy storage technologies used for hybrid electric vehicles and their control end energy balancing techniques 4. Demonstrate different configurations of electric vehicles and charging techniques	1. Acquire the knowledge of basics of I. C. Engine and its components, operation, construction and types. They will also acquire the knowledge of cooling and lubrication of I. C. Engine. 2. Students will demonstrate knowledge of the characteristics of conventional and alternative fuels, fuel supply systems and air induction systems used in I. C. Engine. 3. Understand the process of combustion and factors affecting combustion in I. C. Engines. 4. Develop an understanding of real world engine design issues and an ability to suggest future engine designs for specific Identify the performance parameter and carry out the performance analysis of I. C. Engine and methods to improve it.

Unit I	**[12 Hrs]**
HEV Fundamentals: Vehicle Basics, Vehicle Resistance, Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire—Ground Adhesion and Maximum Tractive Effort, Power Train Tractivc Effort and Vehicle speed, EV powertrain Component Sizing. Hybridization of the Automobile: Basics of EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV) and Vehicle Architecture: Series Hybrid Vehicle, Parallel Hybrid Vehicle, Basics of Fuel Cell Vehicles (FCVs).	
Unit II	**[12 Hrs]**
Fundamental of Drives and Controls of EV using DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC Motor, Design and sizing of traction Motors power Electronics including switching, AC-DC, DC-AC conversion. Electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics.	
Unit III	**[12 Hrs]**
Introduction, Different batteries for EV, Battery characterization, comparison of different energy storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devises, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage Systems and Battery Management System.	
Unit IV	**[12 Hrs]**
Sizing the propulsion motor, sizing the Power Electronics, selecting the energy storage technology, Communications, supporting subsystems. Matching the electric machine and the internal combustion engine (ICE). Introduction to energy management strategies used in hybrid and electric vehicle, Classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.	
Unit V	**[12 Hrs]**
EV Charging Technologies: Classification of different charging technologies far EV charging station, introduction to Grid to Vehicle (G2V), Vehicle to Grid (V2G) or Vehicle to Building (V2B) or Vehicle to Home (V2H) operations, bi-directional EV charging systems, energy management Strategies used in hybrid and electric vehicle, Wireless Power Transfer (VPT) technology for EV charging.	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Hussein	2003	CRC Press, 2003
2.	Electric Vehicle Technology Explained	James Larminie, John Lowry	2012	Wiley Blackwell

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Modern Electric, Hybrid Electric and fuel Cell Vehicles: Fundamentals, Theory and Design.	Mehrdad Ehsani, Yimi Goa, Sebsstin E. Gay and Ali Emadi	2009	CRC Press,
2,	Hybrid Electric Vehicles: Principles and Applications with Practical Prospective	Chris Mi, M. Abul Masur, David Wenzhong Gao	2011	John Wiley & Sons Ltd

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SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT203P	Electric Vehicles Lab	-	-	2	1	25	25	50

Course Objectives	Course Outcomes
1. To learn about the importance of Hybrid Electric vehicle and to ascertain various architecture for a hybrid electric vehicle. 2. To familiarize with various component in hybrid electric vehicle. 3. To gain knowledge about various energy storage devices in hybrid electric vehicles.	1. Choose a proper architecture for a hybrid electric vehicle along with the components. 2. Design and examine battery and other components for various i parameters. 3. Identify various energy storage devices used in hybrid electric vehicle

Minimum 8 experiments to be performed

Expt. No.	Title of the experiment
1	Experiment on selection of hybrid vehicle architecture
2	Experiment on Battery Sizing Calculation for Hybrid Electric Vehicle
3	Experiment of Design of a Battery Pack for Hybrid Electric Vehicle
4	Experiment on simulation of a battery pack for its performance parameters
5	Experiment on Selection of various components of a Hybrid Electric Vehicle based on input parameters
6	Experiment on monitoring Battery parameters during charging
7	Experiment on Simulation to determine the range of Hybrid Electric Vehicle
8	Experiment on selection of various energy storage system of hybrid electric vehicle

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Hussein	2003	CRC Press, 2003
2.	Electric Vehicle Technology Explained	James Larminie, John Lowry	2012	Wiley Blackwell

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Modern Electric, Hybrid Electric and fuel Cell Vehicles: Fundamentals, Theory and Design.	Mehrdad Ehsani, Yimi Goa, Sebsstin E. Gay and Ali Emadi	2009	CRC Press,
2,	Hybrid Electric Vehicles: Principles and Applications with Practical Prospective	Chris Mi, M. Abul Masur, David Wenzhong Gao	2011	John Wiley & Sons Ltd

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AUTOMOTIVE TECHNOLOGY

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT204T(i)	PE – III Automotive Safety Systems	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To provide an in-depth understanding of automotive safety systems, their evolution, and regulatory frameworks. 2. To equip students with knowledge of crash dynamics, vehicle structures, and crashworthiness to enhance occupant protection. 3. To introduce advanced safety technologies such as ADAS, ergonomic design principles, and driver behavior analysis. 4. To familiarize students with passive and active safety equipment, signalling systems, and their role in vehicle safety. 5. To educate students on safety considerations specific to electric vehicles and hazardous goods transport. 6. To explore emerging automotive safety technologies and international standards for modern vehicle systems.	1. Explain the fundamental concepts of automotive safety systems, including active and passive safety mechanisms. 2. Analyze regulatory standards such as CMVR and ARAI norms for vehicle safety compliance. 3. Assess the role of ADAS, ergonomic design, and human factors in enhancing driving safety. 4. Analyze knowledge of restraint technologies, energy absorption methods, and crash dummy analysis in vehicle safety design. 5. Demonstrate an understanding of EV safety protocols, hazardous goods transport regulations, and emergency response measures. 6. Investigate the application of emerging technologies and international automotive safety standards in modern vehicle design.

Unit I **[12 Hrs]**

Introduction to Safety Systems: Definitions and evolution of active and passive safety systems.Historical developments and future trends in automotive safety. **Regulatory Standards**: Central Motor Vehicle Rules (CMVR): Key aspects of compliance requirements, vehicle certification, and mandated safety features per Indian regulations. ARAI Norms for Safety: Overview of testing procedures, certification requirements, and performance benchmarks established by ARAI

Unit II **[12 Hrs]**

Passenger Safety in Public Transport and Private Vehicles: Safety measures and design differences for passenger compartments. Emergency evacuation protocols and occupant protection features are compliant with CMVR and ARAI norms. **Structural Characteristics:** Material properties, vehicle body construction, and structural design. Optimization techniques to enhance crashworthiness. **Crash Dynamics:** Types of collisions (frontal, side, and rollover) and crash testing methodologies. Instrumentation requirements in crash tests.

Unit III **[12 Hrs]**

Advanced Driver Assistance Systems (ADAS): Overview of features such as lane departure warning, adaptive cruise control, collision avoidance, and automatic emergency braking. Integration of sensor technologies (radar, lidar, cameras) and data fusion for enhanced safety.
Ergonomic Design Principles: Anthropometry and its significance in vehicle interior design. Optimal placement of controls and instruments for enhanced safety and comfort.**Safe Driving Techniques:** Examination of driver behaviour, training, and safe driving practices. Strategies for reducing human error and promoting safer driving habits through driver feedback and behaviour modification.

Unit IV **[12 Hrs]**

Passive Safety Equipment: In-depth study of restraint systems including safety belts (and their types), head restraints, and airbags.
Energy Absorption & Crash Dummies: Role of energy-absorbing structures in minimizing occupant injury.Overview of crash dummy requirements and biomechanical modelling for collision analysis. **Road and Vehicle Signalling Systems:** Examination of integrated signalling systems including vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications. Analysis of dashboard warning systems that alert drivers to road conditions and hazards.

Unit V **[12 Hrs]**

Electrical Vehicle (EV) Safety: Safety challenges unique to electric vehicles, including high-voltage system protection and battery safety.EV-specific crash considerations, emergency shutdown protocols, and thermal management of battery packs.
Hazardous Goods Vehicle Safety: Safety considerations for vehicles transporting hazardous materials. Specialized restraint systems, structural modifications, fire suppression systems, and emergency response protocols. **Emerging Technologies and International Safety Standards:** Introduction to advanced lighting systems (Gas Discharge Lamps, LEDs, AFLS, DRL) and international safety standards (e.g., ISO 26262) with applications to both conventional and electric vehicle systems.

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Automotive Safety Systems	N. Balasubramaniam	2017	Tata McGraw-Hill.
2.	Crash Worthiness and Occupant Protection in Transportation System	T.B.Khali , C.M. Nil	1991	Amer Society of Mechanical
3	Automobile Safety	Dr. P.M. Panday,	2014	New Age International Publishers.

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Vehicle Crash Mechanics	Matthew Huang,	1986	CRC Press,
2	Advanced Vehicle Safety Systems	Hideo Takada,	2017	Springer India,
3	Ergonomics in Automotive Design	P. K. Nag,	1013	Tata McGraw-Hill, Volume 1.

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AUTOMOTIVE TECHNOLOGY

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT204T(ii)	PE – III Automotive Testing and Validation	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. Enable the students to synthesize the data and apply the technical concepts in the automotive applications. 2. Enable the students to Innovative and provide solutions by carrying out research. 3. To enable to formulate, solve and analyze engineering problems using mathematical, scientific and engineering principles. 4. Enable to show professional and ethical attitude and maintain a lifelong learning attitude.	1. Classify the vehicle and identify the regulations governing for each vehicle type 2. Perform and analyze the Static & Dynamic test of any vehicle 3. Perform various test related to vehicle engine emissions 4. Test and analyze the performance of vehicle components 5. Perform the tests to be done on the vehicle lighting system

Unit I **[12 Hrs]**

Introduction: Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks.

Unit II **[12 Hrs]**

Static Testing of Vehicle: Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement Of Foot Controls For M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement Of Temporary Cabin For Drive – Away – Chassis.

Unit III **[12 Hrs]**

Dynamics Testing of Vehicle: 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 (petrol & diesel), Indian driving cycle, Vehicle mass emission, Evaporative emission (petrol vehicles), Vehicle Crash Testing.

Unit IV **[12 Hrs]**

Vehicle Component Testing: Horn Testing, Safety Glasses Test: Windscreen 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 GVW<1500 kg), 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.

Unit V **[12 Hrs]**

Vehicle Lighting Testing: Installation requirement for lighting, signalling & reflective devices Installation, Conspicuity & Reflective Marking, Photometry Test: Performance requirement for lighting, signalling and reflective devices - Head lamp, Front lamp, direction indicator lamp, signaling lamp and Warning triangles.

Text Books

S.N.	Title	Authors	Edition	Publisher
1.	Indian Standards (IS)	IS	--	GOI
2.	Automotive Industry Standards (AIS)	AIS	--	AIS

Reference Books

S.N.	Title	Authors	Edition	Publisher
1.	ECE & EC Regulations/Standards	--	--	GOI
2.	Safety Regulations- Society of Indian Automobile Manufacturers	--	--	AIS

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AUTOMOTIVE TECHNOLOGY

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT204T(iii)	PE – III Data Science and Analytics	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To impart introductory knowledge of data science techniques to the students. 2. To make students aware about application of data analysis to engineering and related business problems. 3. To enable students to learn the effect of data science in making automotive systems more secure and interactive.	1. Demonstrate basic data science concepts 2. Apply descriptive analytics to the data 3. Perform analysis of data using hypothesis testing and ANOVA 4. Develop linear and logistic data model

Unit I	**[12 Hrs]**
Introduction to Data Science and Analytics: Introduction to Data Analytics: The Science of Data-Driven Decision Making, Business Context, Data Science, Descriptive Analytics, Predictive Analytics, Prescriptive Analytics, Descriptive, Predictive, and Prescriptive Analytics Techniques, Big Data Analytics, Machine Learning Algorithms, Framework for Data-Driven Decision Making, Challenges in Data-Driven Decision Making and Future	
Unit II	**[12 Hrs]**
Descriptive Data Analytics and Visualization: Introduction to Descriptive Analytics, Data Types and Scales, Structured and Unstructured Data, Cross-Sectional, Time Series, and Panel Data, Types of Data Measurement Scales, Population and Sample, Measures of Central Tendency, Mean ,Median, Mode, Percentile, Decile, and Quartile, Measures of Variation, Range, Inter-Quartile Distance, Variance and Standard Deviation, Measures of Shape-Skewness and Kurtosis, Data Visualization, Histogram, Bar Chart, Pie Chart, Scatter Plot, Box Plot.	
Unit III	**[12 Hrs]**
Hypothesis Testing for Data analytics: Introduction to Hypothesis Testing, Setting Up a Hypothesis Test , Description of Hypothesis, Null and Alternative Hypothesis, Test Statistic, Decision Criteria –Significance Value, One-Tailed and Two-tailed Test, Type I Error, Type II Error, and Power of The Hypothesis Test, Hypothesis Testing for Population mean with Known Variance and unknown Population Variance, Non-Parametric Tests: Chi-Square Tests, Chi-Square Goodness of Fit Tests, Choice of Number of Intervals in Chi-Square Goodness of Fit Test, Test of Independence.	
Unit IV	**[12 Hrs]**
Analysis of Variance for Data analytics: Introduction to Analysis of Variance (ANOVA), Multiple t-Tests for Comparing Several Means, One-way Analysis of Variance (ANOVA), Setting Up an Analysis of Variance, Cochran's Theorem, The F-Test, Two-Way Analysis of Variance (ANOVA).	
Unit V	**[12 Hrs]**
Linear and Logistic Regression: Simple Linear Regression, History of Regression–Francis Galton's Regression Model, Simple Linear Regression, Model Building, Estimation of Parameters, Using Ordinary Least Squares, Interpretation of Simple Linear Regression Coefficients. Validation of the Simple Linear Regression Model, Introduction to Classification Problems, Binary Logistic Regression, Estimation of Parameters in Logistic Regression, Interpretation of Logistic Regression Parameters, Classification Table, Sensitivity, and Specificity, Logistic Regression and Model Diagnostics, Variable Selection in Logistic Regression.	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Business Analytics: The Science of Data-Driven Decision Making.	U Dinesh Kumar	2017	Wiley India Pvt. Ltd, New Delhi.
2.	Doing Data Science	Cathy O'Neil, Rachel Schutt	2014	O'Reilly Media, Inc. CA.

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Introduction to Machine Learning with Python: A Guide for Data Scientists.	Müller A C, Guido S	2017	O'Reilly Media, Inc. CA.
2,	Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python	Bruce P, Bruce A, Gedeck P	2nd Edition, 2020	O'Reilly Media, Inc. CA.

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SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT205T(i)	PE-IV Design of Battery Pack and Thermal Modelling	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To provide knowledge on battery chemistries like Li-ion and Li-polymer and their applications. 2. To familiarize electrochemical processes, series/parallel configurations, and module assembly 3. To understand the aspects of mechanical, thermal and electrical design of a battery pack 4. To familiarize difference aspects f design and testing of a battery pack.	1. Identify different types of Battery chemistry for different applications 2. Designing and assembling battery pack for various mechanical and electrical factors 3. Assessing the role of Battery Management System for different factors involved 4. Test battery pack assembly, thermal evaluation, and performance testing

Unit I	**[12 Hrs]**
Cell Fundamentals & Battery Chemistry: Overview of battery chemistrie (Li-ion, Li-polymer, etc.)-Types of batteries and their applications-Basics of electrochemical processes in batteries-Series and parallel configurations-Module and pack assembly-Cell interconnections.	
Unit II	**[12 Hrs]**
Mechanical and Thermal Design of Battery Pack: fundamental forces acting on a battery pack design, design consideration for the depth of discharge (DOD), the operating voltage, and the energy consumption per kilometer, thermal modeling of a battery pac	
Unit III	**[12 Hrs]**
Electrical Design and Integration of Battery Pack: assembling cells into modules and battery pack, consideration for Voltage drop and current equalization, wiring harness for power deliver and monitoring, electrical protective equipment for a battery pack	
Unit IV	**[12 Hrs]**
Introduction and role of BMS in Battery Pack: Introduction to Battery Management system, role of BMS in efficient operation, monitoring parameters like voltage, current, and temperature, and implementing protection and balancing functions to extend battery life.	
Unit V	**[12 Hrs]**
Design & Testing: Prototyping and testing procedures-Performance evaluation and optimization-Reliability testing and durability assessment.	

Text Books

S.N	Title	Authors	Edition	Publisher
1.	"Battery Systems Engineering"	Christopher Rahn and M. Saiful Islam	2013	CRC Press
2.	Thermal Management of Electric Vehicle Battery Systems	A.Pesaran, M. Keyser, and Y. Kim	2011	SAE International

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Battery Technology Handbook	H. A. Kiehne and E. Di Valentin	2013	CRC Press
2,	Battery Thermal Management Systems for Electric Vehicles	W.J. Zhang and X. Yu	2018	Springer

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SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT205T(ii)	PE-IV Automotive Tribology and Maintenance	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To enable the student to interpret the basics of automobile tribology. 2. To enable the student to select appropriate lubricant for automobile. 3. To make students to carryout comprehensive vehicle maintenance strategy.	1. Interpret nature of friction and wear in various vehicle components like Engine, Transmission system, 2. Predict and develop a complete lubrication requirement of an automobile system. 3. Analyse the effect of tyre construction on friction between tyre and road and tyre wear. 4. Develop procedure of vehicular maintenance of different components.

Unit I **[12 Hrs]**

Introduction to Tribology: Friction, wear and lubrication principles of tribology, thick film lubrication, boundary layer lubrication.
Friction and wear: Laws of friction, causes of friction, types of wear and mechanisms of wear, wear properties of friction and anti-friction metallic and non-metallic materials.
Pneumatic tyres: creep and slip of an automobile tyre, functions of tyre, design features of the tyre surface, mechanism of rolling and sliding, tyre performance on wet road surface.

Unit II **[12 Hrs]**

Lubricants: Solid lubricants, liquid lubricants, properties of lubricants. selection for general applications and special applications such as low temperature, high temperature, extreme pressure, corrosion resistance etc.
Hydrodynamic lubrication: basic concepts, Reynolds equation, plane bearings. design of journal bearings- short and finite bearings, design of bearings with steady load, varying load and varying speed.
Lubrication of automobile systems: Engine lubricating systems, lubrication of piston, piston rings and cylinder liners, lubrication of cam and followers, lubrication of involutes gears, hypoid gears and worm gears, friction aspects of clutch, brakes and belt drive.

Unit III **[12 Hrs]**

Pneumatic tyres: creep and slip of an automobile tyre, functions of tyre, design features of the tyre surface, mechanism of rolling and sliding, tyre performance on wet road surface.

Unit IV **[12 Hrs]**

vehicle maintenance schedules and its importance and list the requirements for different types of service to vehicle. Vehicle washing and cleaning, details of vehicle service, requirement of tools, equipment, consumables, and components for the job and perform Vehicle Service Process.

Unit V **[12 Hrs]**

Wheel balancing and alignment of vehicle, check 19.1 Check and correct the steering geometry with instruments. 22 Automotive Service & Repair the faults, explain the causes and perform repairing & servicing of Steering System defects, brake system and defects in a vehicle brake system, Transmission Oil replacement. different types of engine belts, Suspension system, Engine Vacuum Test, Compression Pressure Test, and Engine Oil Pressure Test, Gear box

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Principles and applications of tribology	Desmond F. Moore	1st edition 2013	Pergamon;
2.	Tribology in machine Design	T.A. Stolarski	1999	Butterworth-Heinemann Ltd

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	Introduction to Tribology of Bearings	B.C. Majumdar	2008	S Chand New Delhi
2.	Vehicle Dynamics	Dr Georg Rill	2003	SAE

SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT205T(iii)	PE-IV Vehicle Body Engineering	4	-	-	4	40	60	100

Course Objectives	Course Outcomes
1. To introduce the types, construction of car, bus and truck bodies. 2. To provide insights on body mechanisms, trim and materials. 3. To familiarize on applications of structural analysis to the car bodies.	1. Evaluate the different Construction Methodologies of the Vehicle Bodies. 2. Apply the Regulations for vehicle body construction 3. Select the Body Materials and Trims 4. Perform structural analysis of the vehicle body structure

Unit I **[12 Hrs]**

Car Body Details: Types: compact, hatch-back, sedan, convertibles, limousine, estate car, racing and sports car. Car body construction; design criteria, prototype making, Body In white, creating the inner panels, underfloor panels, detailing of class A surfaces (Flanges, seating, hemming. Electric vehicle body design.Vehicle body materials - steel, light alloys, plastics, textiles, glass, wood, aluminum materials, adhesives and their properties, corrosion and their prevention.

Unit II **[12 Hrs]**

Bus Body Details: Types: mini bus, single decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions. Constructional details: frame construction, double skin construction, types of metal sections used, Conventional and integral type construction, Bus Body Code and Regulations. Code for Truck Cabs, truck Bodies and trailers. Bus and Truck Body Manufacturing techniques. Indian Bus and Truck body building scenario and the way forward.

Unit III **[12 Hrs]]**

Commercial Vehicle Details: Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls. Driver's cab design. BODY Materials, Trim And Mechanisms: Steel sheet, timber, plastic, GRP, properties of materials; Corrosion, anticorrosion methods. Body trim items. Body mechanisms. Born electric Vehicle-body types and materials.

Unit IV **[12 Hrs]**

Structural Analysis of the Body: Loads experienced by the body structure under various vehicle operating conditions, Simple Structural Surfaces (SSS) method and its application to various types of car bodies, the effect of internal stresses, design synthesis, etc.

Unit V **[12 Hrs]**

. Hand tool study, power tool and equipment, shop safety, minor repairs, passenger compartment service. Major body repair - frame repair, frame/body damage.
Basic composition of Paint and different types of paint, refinishing process - Materials used, paint removal, preparing bare metal, prime coat selection, final sanding, masking, surface cleaning. Spray guns, air brushes - single and double action, spray booth types. Rust repair procedures.

Text Books

S.N	Title	Authors	Edition	Publisher
1.	Vehicle Body Engineering	Janusz Pawłowski	1969	Business Books
2.	Motor Vehicle Structures: Concepts and Fundamentals	Jason C. Brown, A. John Robertson & Stan T. Serpento	2002	Butterworth-Heinemann,

Reference Books

S.N	Title	Authors	Edition	Publisher
1.	The Automotive Body, Vol 1 Components Design,	L. Morel, J. P. Sinaume	2011	ISTE Ltd. and Wiley
2	Automobile Body Engineering	D.J. Leeming	1st edition	Iliffe Books Ltd., London

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SECOND SEMESTER

Course Code	Course Name	Th	Tu	Pr	Credits	Evaluation		
						CA	ESE	Total
26AT206P	IPR/ Quantitative Methods/ Design of Experiments	-	-	2	1	50	-	50

Course Objectives	Course Outcomes
1. To familiarize students with the fundamentals and legal aspects of Intellectual Property Rights (IPR). 2. To develop skills in applying statistical methods for engineering research and decision-making. 3. To enable students to design and analyze experiments for quality and process improvement. 4. To foster innovation and awareness of patent filing and commercialization. 5. To integrate software tools for statistical analysis and experimental design.	1. Explain various types of Intellectual Property and related legal frameworks. 2. Conduct patent search, interpret patent information, and understand filing procedures. 3. Apply statistical tools for data analysis and inference in engineering research. 4. Design effective experiments using principles of DOE for process optimization. 5. Utilize statistical software tools to analyze experimental data and draw conclusions.

Module I	**[3 Hrs]**
Intellectual Property Rights Introduction to IPR: Definition, scope, and importance, Types of IPR: Patents, Copyrights, Trademarks, Trade Secrets, Industrial Designs, Indian IPR system and international IPR systems (WIPO, TRIPS, PCT),Case studies: IPR in academia and industry.	
Module II	**[3 Hrs]**
Patent Search and Technology Commercialization Patent databases: Google Patents, Espacenet, IPO India portal, Patent search strategies and prior art analysis, Patent filing process (India and international),IP commercialization, licensing, technology transfer.	
Module III	**[3 Hrs]**
Quantitative Methods – Statistical Analysis Descriptive statistics: Mean, Variance, Standard Deviation, Probability distributions: Normal, Binomial, Poisson, Hypothesis testing: t-test, z-test, chi-square test, Correlation and linear regression analysis, Introduction to software tools: Excel/SPSS/Minitab.	
Module IV	**[3 Hrs]**
Design of Experiments – Basic Concepts Introduction to DOE: Objectives, terms, and benefits,Principles of experimental design: Randomization, Replication, Blocking,Types of designs: CRD, RBD, Latin Square,Factorial design: Full and Fractional,ANOVA for design interpretation.	
Module V	**[3 Hrs]**
Advanced DOE and Industrial Applications Taguchi methods: Orthogonal arrays, signal-to-noise ratio, Response Surface Methodology (RSM),Case studies: Applications in manufacturing, product development, DOE using Minitab or Report writing and result interpretation.	

Text Books

S.N	Title	Authors	Edition	Publisher
1	Law Relating to Intellectual Property	B. L. Wadhera	6th Edition.2021	Universal Law Publishing
2	Design and Analysis of Experiments	Douglas C. Montgomery	10th Edition,2019	Wiley India

Reference Books

S.N	Title	Authors	Edition	Publisher
1	Statistics for Engineers and Scientists	William Navidi	5th edition.2021	McGraw-Hill Education
2	Intellectual Property Rights: Unleashing the Knowledge Economy	Prabuddha Ganguli	1st Edition ,2001	Tata McGraw Hill

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