Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
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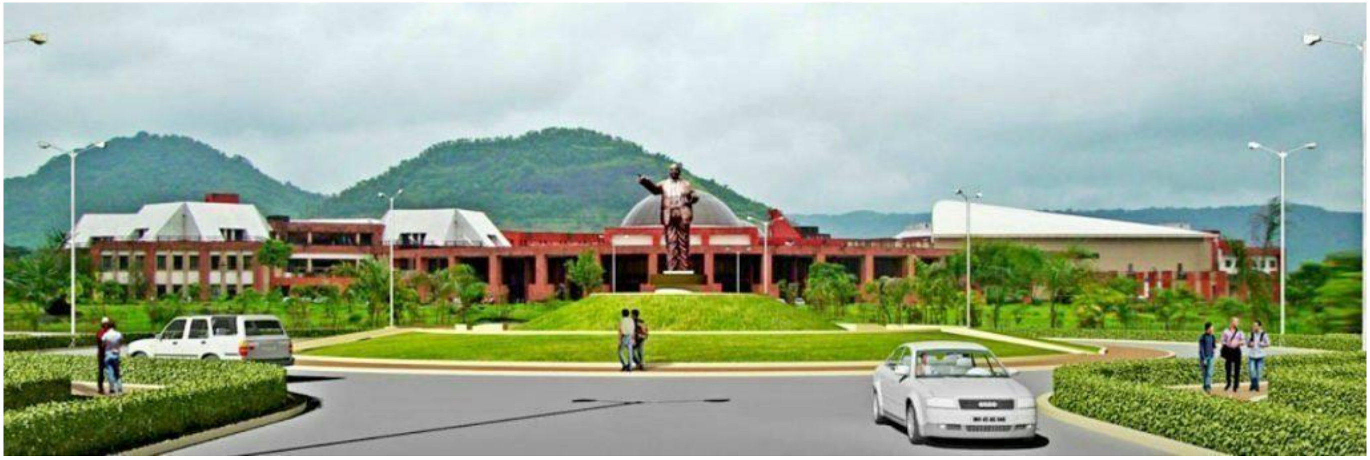
Course Structure and Contents
for
M.Tech. in Electric Vehicle Technology
(For Affiliated Institutes Only)

Syllabus as per the guidelines of National Education Policy 2020
To be implemented from Academic Year 2024-25.



Vision

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

Mission

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

M.Tech. in Electric Vehicle Technology

Program Educational Objectives are broad statements that describe the career and professional accomplishments that the Electrical Vehicle Technology program is preparing graduates to achieve.

Programme Educational Objectives (PEOs)

No.	PEO
PEO1	To emerge as competent professionals and leaders in Electrical Vehicle Technology, contributing to global enterprises while upholding a strong background in ethics and societal responsibilities.
PEO2	To possess the ability to independently conduct research, investigation, and development work in Electrical Vehicle Technology, actively contributing to advancements in the field.
PEO3	To demonstrate a high level of competence in addressing diverse and complex challenges within the domain of Electrical Vehicle Technology, and apply contemporary engineering tools and procedures for sustainable development, while promoting a culture of self-learning and ethical practice in their professional endeavours.
PEO4	To enable post graduates to carry out innovative and independent research work, disseminate the knowledge in Academia/Industry/Research Organizations to develop systems and processes in the related field.

Programme Outcomes (POs)

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

No.	PO
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering

	problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** User research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Department PSO's

PSO-1: Engineering graduates can explore knowledge of electrical & electronics engineering in core as well as multidisciplinary areas in innovative, dynamic and challenging environment, for the research based teamwork.

PSO-2: Engineering graduates can provide hands on experience in the fields of Non-conventional and Renewable Energies.

Abbreviations

PEO : Program Educational Objectives

PO : Program Outcomes

CO : Course Outcomes

L : No. of Lecture hours (per week)

T : No. of Tutorial hours (per week)

P : No. of Practical hours (per week)

C : Total number of credits

PCC : Professional Core Course

OEC : Open Elective Course

PEC : Professional Elective Course

AC : Audit Course

AEC : Ability Enhancement Course

VEC : Vocational Education Course

IKS : Indian Knowledge Society

MDM : Multidisciplinary Minor

ESE-Th: End Semester Exam of Theory Paper

ESE-PR/OR: End Semester Exam of Practical or oral/Viva-voce

CA: Continuous Assessment

M.Tech in Electric Vehicle Technology 2024-2025 Structure and Syllabus as per NEP 2020.

SEM-I											
Course Code	**Type of Course**	**Course Name**	**L**	**T**	**P**	**Credit**	**ESE-Th**	**CA**	**Mid Sem**	**ESE-PR/OR**	**Total**
		Professional Core(Theory)									
	PCC	Battery Chemistry & Charging Technology	3	1		4	60	20	20		100
	PCC	EV motors and Controllers	3	1		4	60	20	20		100
	PCC	Electric Vehicle Structure Design	3	1		4	60	20	20		100
	OEC	Research Methodology & IPR	3			3	60	20	20		100
	PCC	EV motors and controllers Lab			2	1		25		25	50
		Professional Elective(Theory)									
	PE	Professional Elective-I	3			3	60	20	20		100
	PE	Professional Elective-II	3			3	60	20	20		100
	AC	Constitution of India	2			Audit				50	50
					Total Credit	**22**					**600**

Professional Elective-I	**Professionl Elective-II**
a)Fundamentals of design for EV	a)Power Electronics interface
b)Fundamentals of Automotive systems	b)Automobile design explorations
c)Fuel cell technology	c) Energy Storage Techniques
d)Software Development for EVs	d)Wireless sensor network
e)Embedded system hardware and design	e) Artificial intelligence in EV

SEM-II										
Course Code	**Type of Course**	**Course Name**	**L**	**T**	**P**	**Credit**	**Th**	**CA**	**ESE PR/OR**	**Total**
		Professional Core(Theory)								
	PCC	Electric Drives for EVs	3	1		4	60	40		100
	PCC	Automotive HVAC & thermal management system	3	1		4	60	40		100
	PCC	Electric and Hybrid Vehicles	3	1		4	60	40		100
		Professional Core(Lab)								
	PCC	HVAC & Thermal management Lab			2	1		25	25	50
	PCC	Seminar-I			2	1			50	50
		Professional Elective(Theory)								2
	PE	Professional Elective-III	3			3	60	40		100
	PE	Professional Elective-IV	3			3	60	40		100
	AC	English for Research Paper Writing	2		Audit				50	50
					Total Credit	**20**				**650**

Professional Elective-III	**Professional Elective-IV**
a)Smart Grid and Advanced charging Infrastructure	a)Energy Management
b)Design, Testing and certification of EV	b)Automotive Safety
c)Advanced materials in design	c)Life cycle analysis of EV
d)IoT Technology in EV	d)Computational techniques and optimization
e) Charging Infrastructure	e)Traffic engineering & Intelligent transportation

SEM-III										
Course Code	**Type of Course**	**Course Name**	**L**	**T**	**P**	**Credit**	**Th**	**CA**	**ESE PR/OR**	**Total**
		Professional Core(Theory)								
	PCC	Self-Study using NPTEL	4			4	60	40		100
	PCC	Control Systems for Electric Vehicle	3	1		4	60	40		100
	PCC	Seminar-II			2	1		50	50	100
	PCC	Dissertation Phase-I				10		50	50	100
					Total Credit	**19**				**400**

Self-Study using NPTEL
1) Electric Vehicles - Part 1(By Prof. Amit Jain | IIT Delhi)
2) Fundamentals of Electric Vehicles: Technology & Economics-Dr Ashok Jhunjhunwala,IITM
3) Electric Vehicle Technology for Academia By Dr G.A.Rathy, Dr R. Suja Mani Malar | National Institute of Technical Teachers Training and Research, Chennai
4) Introduction to Electric and Hybrid Electric Vehicle By Dr. R. N. Patel and Dr Lalit Kumar Sahu | Chhattisgarh Swami Vivekanand Technical University
5) Intellectual Property Rights and Competition Law By Prof. KD Raju, Prof. Niharika Sahoo Bhattacharya | IIT Kharagpur
6) Project Management By Prof. Raghu Nandan Sengupta | IIT Kanpur

SEM-IV											
Course Code	**Type of Course**	**Course Name**	**L**	**T**	**P**	**Credit**	**Th**	**CA**	**PR/OR**	**Total**
	PCC	Industrial Internship or Dissertation Phase-II			20	20		100	100	200
					Total Credit	**20**				**200**

Semester-I
Battery Chemistry and Charging technology

Course Code:	PCC	Battery chemistry and charging technology	3-1-0	4 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Basics of Battery and cells
Course Outcomes: At the end of the course, students will be able to:

CO1	Learn the battery construction, performance analysis and Battery management system.
CO2	Analyze the Smart charging strategies for Electric Vehicles.
CO3	Understand the control architecture and algorithms for smart charging.
CO4	Learn role of of AI in battery charging strategy.
CO5	To evaluate the infrastructure requirements for EV charging.

Mapping of course outcomes with program outcomes

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

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

Course Contents:

UNIT-I: Introduction (8 Hours)

Principles of operation of cells and batteries, Electrochemical principles and reactions, Types of batteries, Fuel cells, Super capacitors, Selection and application of energy storage systems for electric vehicle system, Brief introduction to Lead-acid, Ni-based, Lithium-Ion and Sodium-Ion batteries, Battery performance parameters, Battery sizing.

UNIT-II: BATTERY MANAGEMENT SYSTEM (10 Hours)

Selection of battery for EV, Traction battery pack design, Requirement of battery monitoring, Battery state of charge estimation methods, Battery cell equalization problem and solution, Protection interface, Energy and power estimation, Battery thermal management system, Components of battery management system, Battery packsafety, Battery standards & tests.

UNIT-III: SMART CHARGING OF ELECTRIC VEHICLES (8 Hours)

Charger types and description of charging technologies, Connectors, Relevant standards, Communication protocols, Smart Control functionalities, Commercially available EV chargers, Wireless charging of batteries, Commercially available smart charging technologies and products, Smart EV charging projects National and International.

UNIT-IV:EV CHARGING STRETEGIES BASED ON CONTROL ARCHITECTURE (5 Hours)

Centralized control, Decentralized control, Distributed control, Hierarchical control, Local control, Smart charging based on optimization algorithms, AI/Machine learning based charging strategy

UNIT-V: - INFRASTRUCTURE FOR EV CHARGING (10 Hours)

Principles for location planning of EV charging stations, Geospatial analysis and locations, Land allocation, Off-grid charging with renewable sources. Improving the utilization of the grid with V2G concept, Grid planning with EV charging stations, Metering or pricing with commercial charging, Regulatory framework for charging stations, Roles of DISCOMs, Safety provisions for the EV charging stations, Battery swapping concept a critical overview, Grid integration and stability issues with Vehicle to Grid, Harmonic and power quality issues associated with high power commercial charging.

REFERENCE BOOKS:	
1.	NITI Aayog report on "Smart charging strategies and technologies for Electric Vehicles" Zakir Rather, Payal Dahiwale, Dhanuja Lekshmi and others
2.	NITI Aayog handbook on "Electric Vehicle Charging Infrastructure Implementation Version-1" Amitabh Kant, Randheer Singh, Sanjeev Kumar Kassi and others
3.	James Larminie, John Lowry, Electric Vehicle Technology Explained, John Wiley & Sons.
4.	Sandeep Dharmeja, Electric Vehicle Battery Systems, Newnes.
5.	Shichun Yang, Xinhau Liu, Shen Li, Cheng Zhang, Advanced Battery Management System for ElectricVehicles, Springer
6.	Chung Chow Chan, K. T. Chau, Modern Electric Vehicle Technology, Oxford University Press.
7.	Qiuwei Wu, Grid Integration of Electric Vehicles in Open Electricity Markets, John Wiley & Sons, Ltd.

EV motors and Controllers and EV motors and controllers

Course Code:	PCC	EV motors and Controllers and EV motors and controllers	3-1-0	4 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of Electric motors working, Types of Electric Motors .
Course Outcomes: At the end of the course, students will be able to:

CO1	Select appropriate type of motor to be used in electric vehicle.
CO2	Select appropriate type Converter and Chopper.
CO3	Evaluate VSI and CSI Fed Induction Motor Control.
CO4	Design field and Torque Control techniques.
CO5	Apply the required control strategy to the Electric Vehicle motors

Mapping of course outcomes with program outcomes

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

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

Course Contents:

UNIT I: ELECTRIC VEHICLE MOTORS (8 Hrs)

Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control. Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives – Basic structure, Drive Convertor, Design

UNIT II: CONVERTER AND CHOPPER CONTROL (8 Hrs)

Principle of phase control – Series and separately excited DC motor with single phase and three phase converters – waveforms, performance parameters, performance characteristics Operation with freewheeling diode schemes; Drive employing dual converter. Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control.

UNIT III: VSI AND CSI FED INDUCTION MOTOR CONTROL (7 Hrs)

AC voltage controller fed induction machine operation – Energy conservation issues – V/f operation theory – requirement for slip and stator voltage compensation. CSI fed induction machine – Operation and characteristics - PWM controls.

UNIT IV: FIELD ORIENTED AND DIRECT TORQUE CONTROL (10 Hrs)

Field oriented control of induction machines – Theory – DC drive analogy – Direct or Feedback vector control - Indirect or Feed forward vector control – Flux vector estimation – Space Vector Modulation control. Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy – optimum switching vector selection – reduction of torque ripple, methods.

UNIT V: ELECTRIC VEHICLE CONTROL STRATEGY (8 Hrs)

Vehicle Supervisory Control, Mode Selection Strategy (Parallel mode, Power Split Mode, Engine Brake mode, Regeneration mode), Hybrid Modes, Modal Control Strategy.

ICA should consist of minimum four assignments based on above syllabus and one mini project related with control of electric motors.

REFERENCE BOOKS:	
1.	Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill,2000.
2.	R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice- Hall of India,Pvt. Ltd., New Delhi, 2003.
3.	Austin Hughes, "Electric Motors and Drives – Fundamentals, Types and Applications", Elsevier – a division of Reed Elsevier India private Limited, New Delhi, 2006

Electric Vehicle Structural Design

Course Code:	PCC	Electric Vehicle Structural Design	3-1-0	4 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

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

Mapping of course outcomes with program outcomes

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

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

Course Contents:

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

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

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

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

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

Text Books

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

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

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

Research Methodology and IPR

Course Code:	OEC	Research Methodology and IPR	3-0-0	3 Credit

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites:

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

CO1	Define a research problem and use appropriate research methodology
CO2	Examine data using different hypothesis tests and make conclusions about acceptance or rejection of sample data.
CO3	Analyze numerical data, using standard procedures of probability theory to predict the Performance.
CO4	Develop a mathematical model and analyze the prediction capabilities
CO5	Write a research paper and research proposal.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I: Research Problem and Research Design [7 Hrs]

Objectives, Motivation, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Criteria of Good Research Definition and Feasibility study of research problem, Sources of research problem, Meaning of Hypothesis, Characteristics of Hypothesis, Errors in selecting a research problem, Concept & need of research design

Unit II: Applied Statistics [7 Hrs]

Measures of Variability: Standard Deviation, variance, Quartiles, Interquartile Range Inferential Statistics: Statistical Significance (p values), Pearson's r test, t- test, Chi square test,

Unit III: Probability [7 Hrs]

Sampling, Types of Sampling, Probability Distribution: Binomial Distribution, Poisson Distribution, Normal Distribution, Case Study: Develop a model for Prediction and Decision Making for the data set using open-source software

Unit IV: Research Report writing and Publication [7 Hrs]

Research Report: Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing. Publishing Research work: Selection of suitable journal for publishing research work, Open access Vs Subscription Journals, identifying indexing of selected journals, Impact factor of the journal, structure of research paper, Check for plagiarism of the article, Research paper submission and review process.

Unit V: Intellectual property Rights [7 Hrs]

Definition of IPR, Classification of IP, Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents. Prior Art Search, Patentability Criteria, Patent Filing Procedure, Forms and Fees, Case Study of Patent, Copyright.

Textbooks:

1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2nd Edition, 1985
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition.,2010.
3. Ramakrishna B and Anil Kumar H S., Fundamentals of IPR, Notion Press, 2016
4. Virendra Kumar Ahuja, IPR in India, LexisNexis Butterworths Wadhwa Nagpur, 2017

Reference Books:

1. Stuart Melville and Wayne Goddard, Research methodology: An Introduction for Science & Engineering Students
2. S.D. Sharma, Operational Research, Kadar Nath Ram Nath & Co.

EV motors and controllers Lab

Course Code:	PCC	EV motors and Controllers and EV motors and controllers Lab	0-0-2	1 Credit

Teaching Scheme	Examination Scheme
Lecture: 2 Hrs/week	Continuous Assessment: 25 Marks End Semester Exam: 25 Marks

Pre-Requisites: Knowledge of Electric motors working, Types of Electric Motors.
Course Outcomes: At the end of the course, students will be able to:

CO1	Select appropriate type of motor to be used in electric vehicle.
CO2	Select appropriate type Converter and Chopper.
CO3	Evaluate VSI and CSI Fed Induction Motor Control.
CO4	Design field and Torque Control techniques.
CO5	Apply the required control strategy to the Electric Vehicle motors

Mapping of course outcomes with program outcomes

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

All experiments from the List:

1. To study different types of motors used in EVs.
2. Analyze the characteristics of DC motors
3. Study the performance of induction motors
4. Investigate the characteristics of PMSMs
5. Understand the concept and implementation of regenerative braking.
6. Integrate a motor with its controller and test the system
7. To diagnosing and troubleshooting motor-controller systems.
8. Optimize the efficiency of motor-controller systems

Professional Elective-I

Fundamentals of design for EV

Course Code:	PEC	Fundamentals of design for EV	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Basics of design engineering.
Course Outcomes: At the end of the course, students will be able to:

CO1	Identify design requirements and standards for EVs
CO2	Integrate motors and transmission systems in EVs
CO3	Design and integrate battery systems for electric vehicles
CO4	Evaluate and optimize regenerative braking systems.
CO5	Apply principles of sustainable design in EV development

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I: Introduction **(7 Hours)**
Definition and classification of EVs, Historical development and future trends, Key Components of EVs, EV Architecture, Design Requirements and Standards

Unit II: Electric Powertrain Design **(7 Hours)**
Electric Motors for EVs, Power Electronics, Transmission Systems, Thermal Management,

Unit III: Battery Systems and Energy Storage **(7 Hours)**
Types of batteries (Li-ion, NiMH, solid-state) and their characteristics, Selection criteria for EV batteries, Functions and components of BMS, Design and optimization of BMS for EVs, Energy Storage Integration, Charging Infrastructure

Unit IV: Vehicle Dynamics and Control Systems (7 Hours)
Longitudinal, lateral, and vertical dynamics, Dynamics modelling and simulation techniques, Control Systems in EVs, Regenerative Braking Systems, Advanced Driver Assistance Systems (ADAS).

Unit V: Sustainable Design and Lifecycle Analysis (7 Hours)
Importance of sustainability in EV design, Methodologies for conducting LCA, Evaluation of energy consumption and emissions throughout the lifecycle, Recycling and disposal of EV components, Strategies for extending the lifecycle of EVs.

Reference Books

1. "Electric Vehicle Technology Explained" by James Larminie and John Lowry
2. "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain
3. "Fundamentals of Vehicle Dynamics" by Thomas D. Gillespie
4. "Battery Management Systems: Design by Modelling" by Gregory L. Plett
5. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi

Fundamental of Automotive Systems

Course Code:	PEC	Fundamental of Automotive Systems	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: None

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

CO1	Identify the different parts of the automobile.
CO2	Explain the working of various parts like engine, transmission, clutch, brakes etc.,
CO3	Demonstrate various types of drive systems; front and rear wheels, two and four wheel drive.
CO4	Apply vehicle troubleshooting and maintenance procedures.
CO5	Analyze the environmental implications of automobile emissions. And suggest suitable regulatory modifications.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit I: Introduction **(7 Hours)**
Vehicle specifications, Classifications, Chassis layout, Frame, Main components of automobile and articulatedvehicles; Engine cylinder arrangements, Power requirements, Tractive efforts and vehicle performance curves.

Unit II: Steering and Suspension Systems **(7 Hours)**
Steering system; Principle of steering, Centre point steering, Steering linkages, Steering geometry and wheelalignment, power steering.
Suspension system: its need and types, Independent suspension, coil and leaf springs, Suspension systems for multi-axle vehicles, troubleshooting and remedies.

Unit III: Transmission System **(7 Hours)**

Clutch: its need and types,

Gearboxes: Types of gear transmission, Shift mechanisms,

Over running clutch, Fluid coupling and torque converters, Transmission universal joint, Propeller shaft, Front and rear axles types, Stub axles, Differential and its types, Four wheel drive.

Unit IV: Brakes, Wheels and Tyres **(7 Hours)**

Brake: its need and types: Mechanical, hydraulic and pneumatic brakes, Disc and drum type: their relative merits,Brake adjustments and defects, Power brakes

Wheels and Tyres: their types; Tyre construction and specification; Tyre wear and causes; Wheel balancing.

Unit V: Electrical Systems **(7 Hours)**

Construction, operation and maintenance of lead acid batteries, Battery charging system, Principle and operation of cutout and regulators, Starter motor, Bendix drive, Solenoid drive, Magneto-coil and solid stage ignition systems, Ignition timing.

Vehicle Testing and Maintenance

Need of vehicle testing, Vehicle test standards, Different vehicle tests, Maintenance: trouble shooting and service procedure, over hauling, Engine tune up, Tools and equipment for repair and overhauling, Pollution due to vehicleemissions, Emission control system and regulations.

Texts:

1. Kripal Singh, “Automobile Engineering”,Vol.I and II, Standard Publishers.
2. G.B.S.Narang,“Automobile Engineering”,Dhanpat Rai and Sons.

References:

1. Joseph Heitner, “Automotive Mechanics”, East-West Press.
2. W.H. Crouse, “Automobile Mechanics”, Tata McGraw Hill Publishing Co.

Fuel Cell Technology

Course Code:	PEC	Fuel Cell Technology	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of applied mechanics, automobile engineering is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Explain types of fuel cells and their applications
CO2	Identify the challenges in hydrogen production and its storage
CO3	Demonstrate the working principle of fuel cells and its process design
CO4	Classify materials for electrodes and testing of different cells
CO5	Demonstrate the processing of fuels for the fuel cell

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Overview of Fuel Cells: (7 Hours)
What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

UNIT-II: Fuels for Fuel Cells: (7 Hours)
Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others, liquid hydrogen and compressed hydrogen-metal hydrides, alkaline fuel cell.

UNIT-III: Fuel cell electrochemistry: (7 Hours)
Electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents, current density, power density, potential and thermodynamics of fuel cell, Introduction to direct methanol fuel cell. Fuel cell process design: Main PEM fuel cell components,

materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

UNIT-III: Fuel cell Stack: (7 Hours)

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling.

UNIT V: Fuel processing: (7 Hours)

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

REFERENCE BOOKS:	
1.	O' Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY (2006).
2.	Bard, A. J. , L. R., Faulkner, Electrochemical Methods, Wiley, N.Y. (2004) Ref Book
3.	Basu, S. (Ed) Fuel Cell Science and Technology, Springer, N.Y. (2007)
4.	Liu, H., Principles of fuel cells, Taylor & Francis, N.Y. (2006).
5.	Barbir F., PEM Fuel Cells: Theory and Practice, 2nd edition, Elsevier/Academic Press, 2013.
6.	Subhash C., Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, Elsevier Advanced Technology, 2003.
7.	Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.

Software Development for EVs

Course Code:	PEC	Software Development for EVs	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Design and implement advanced battery management algorithms for SoC estimation, thermal management, and fault detection.
CO2	Develop and optimize software for electric powertrain control, including techniques like FOC and regenerative braking.
CO3	Use software required for Energy distribution between battery and auxiliary systems, thermal management.
CO4	Design and implement vehicle Supervisory control, energy management, diagnostics, and fault tolerance software.
CO5	Develop and validate ADAS and autonomous driving software with perception, decision-making, and control algorithm

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Battery Management System (BMS) Software
Purpose: Manages the state, health, and safety of the battery pack.
Functions: State of Charge (SoC) estimation, State of Health (SoH) monitoring, thermal management, cell balancing, fault detection.
Examples: Altair Battery Designer, BatteryCAD
Unit-II: Powertrain Control Software
Purpose: Controls the electric motor and power electronics to optimize performance and efficiency.
Functions: Motor control algorithms (FOC, DTC), inverter management, regenerative braking control.

Examples: dSPACE Automotive Simulation Models (ASM), Simulink (MATLAB) for model-based design

Unit-III: Vehicle Control Unit (VCU) Software
Purpose: Integrates various subsystems (e.g., BMS, powertrain, HVAC) and coordinates their operation.
Functions: Supervisory control, energy management, diagnostics, and fault tolerance.
Examples: ETAS INCA, Vector CANoe for network simulation and testing

Unit-IV: Energy Management Software
Purpose: Optimizes the use of energy within the vehicle to enhance efficiency and performance.
Functions: Energy distribution between battery and auxiliary systems, thermal management.
Examples: AVL CRUISE, Autonomie by Argonne National Laboratory

Unit-V: Advanced Driver Assistance Systems (ADAS) and Autonomous Driving Software
Purpose: Enhances driving safety and enables autonomous driving capabilities.
Functions: Perception (sensor data processing, object detection), decision making (path planning, obstacle avoidance), control (adaptive cruise control, lane keeping).
Examples: NVIDIA DRIVE, Apex.AI

References:

1. **"Electric Vehicle Technology Explained"** by James Larminie and John Lowry
2. **"Battery Management Systems for Large Lithium Ion Battery Packs"** by Davide Andrea
3. **"Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives"** by Chris Mi
4. **"Advanced Electric Drive Vehicles"** by Ali Emadi
5. **"Autonomous Driving: Technical, Legal and Social Aspects"** by Markus Maurer et al.

Embedded System Hardware and Design

Course Code:	PEC	Embedded System Hardware and Design	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites:
1. Microprocessor & Microcontroller concepts and applications
2. Assembly language concepts
3. Operating system concepts
4. Computer organization and architecture concepts
5. Design analysis of different day to day equipment's
6. Basics of all electronics components

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

CO1	Understand basic concept of embedded systems.
CO2	Apply and analyze the applications in various processors and domains of embedded system.
CO3	Analyze and develop embedded hardware and software development cycles and tools.
CO4	Analyze to understand what a microcomputer, core of the embedded system.
CO5	Remember the definitions of ASICs, PLDs, memory, memory interface.
CO6	Analyze to understand different concepts of a RTOS, sensors, memory interface, communication interface.

Mapping of course outcomes with program outcomes

PO→ CO ↓	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CO1	3											
CO2	2	3										
CO3	2	2	3		2							1
CO4	3	2			2							1
CO5	2											
CO6	3	2										1

Course Contents:

UNIT-I: Introduction to Embedded Systems **(7 Hours)**

Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics and Quality Attributes of Embedded Systems.

UNIT-II: Typical Embedded System **(7 Hours)**

Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Communication Interface: Onboard and External Communication Interfaces.

UNIT-III: Embedded Firmware **(7 Hours)**

Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Embedded Firmware Design Approaches and Development Languages.

UNIT-IV: - RTOS Based Embedded System Design **(7 Hours)**

Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multi processing and Multi tasking, Task Scheduling.

UNIT-V: - TASK COMMUNICATION **(7 Hours)**

Shared Memory, Message Passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/Synchronization Issues, Task Synchronization Techniques, Device Drivers, How to Choose an RTOS.

REFERENCE BOOKS:	
1.	Introduction to Embedded Systems - Shibu K.V, Mc Graw Hill.
2.	Embedded Systems - Raj Kamal, TMH.
3.	Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
4.	Embedded Systems – Lyla, Pearson, 2013.
5.	An Embedded Software Primer - David E. Simon, Pearson Education.

Professional Elective-II
Power Electronics Interface

Course Code:	PCC	Energy Management	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of applied mechanics, automobile engineering is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Differentiate between operational behavior of IGBT and MOSFET and applications of devices.
CO2	Analyze performance parameters of uncontrolled and controlled rectifiers.
CO3	Evaluate different PWM schemes of Voltage Source Inverters.
CO4	Design different switched mode power supplies.
CO5	Develop a typical driver for power electronic switch.

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Power Semiconductor Switches: **(7 Hours)**
Desired Characteristics in Controllable Switches, Comparison of Controllable Switches, Power MOSFET – Structure, Characteristics, Operation, Switching characteristics, Operation Limitation and Safe Operating Area, IGBT – Structure, Characteristics, Latchup in IGBT, Operation, Switching characteristics, Operation Limitation and Safe Operating Area, Comparison of Power MOSFET and IGBT, SiCMOSFET.

UNIT-II: AC/DC Rectifiers: **(7 Hours)**
Operation of Single-Phase Uncontrolled Rectifier, Single Phase Fully Controlled Rectifiers, Three Phase Uncontrolled Rectifier, Three Phase Fully Controlled Rectifier

with RL and RLE load. Performance Parameters of controlled converters –Input Displacement Factor, Distortion Factor, Power Factor and Total Harmonic Distortion Power Factor Improvement Techniques, Multipulse Converters.

UNIT-III: Pulse Width Modulated Inverters: **(7 Hours)**

Concept of Switched Mode Inverters, Pulse-Width- Modulated Switching Scheme, Square-Wave Switching Scheme, PWM Of Single-Phase Inverters, PWM of Three Phase Inverter, Effect of Blanking Time on Voltage in PWM Inverters, Concept of Zero Vector in PWM, Space Vector PWM, Hysteresis Current Control, Rectifier Mode of Operation of PWM Inverter Matrix Converter – Principle, Operation and Modulation Schemes of Matrix Converter.

UNIT-IV: Switched Mode Power Supply: **(7 Hours)**

Step-Down (Buck) Converter, Step-up (Boost) Converter, Buck-Boost Converter, Cuk dc-dc Converter, Full Bridge dc-dc Converter, Isolated Converters - Forward Converter, Flyback Converter.

Modeling and Control of Power Electronic Converters:

Types of models – Switched model, average model, large signal and small signal model, Switched model of power electronic converter, Classical average model of converter, generalized average model, Control Principles of Power Electronic Converters used in Electric Vehicles, Linear Control Approaches for Power Converters – A case study.

REFERENCE BOOKS:	
1.	Mohan, Ned, and Tore M. Undeland. Power electronics: converters, applications, and design. John wiley& sons, 2007
2.	Rashid, Muhammad H., ed. Power electronics handbook. Butterworth-Heinemann, 2017
3.	Bose, Bimal K. Modern power electronics and AC drives. Vol. 123. Upper Saddle River, NJ: Prentice hall, 2002.
4.	Mohan, Ned. Power electronics: a First Course. Wiley, 2011
5.	Sen, Paresh Chandra. Thyristor DC drives. John Wiley & Sons, 1981

Automobile design explorations

Course Code:	PEC	Automobile design explorations	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of applied mechanics, automobile engineering is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various forms and shape in sketching
CO2	Create a vehicle model using different materials
CO3	Learn various packaging, assembly processes in automobile
CO4	Draw vehicle body with different systems using a CAD model
CO5	Identify various materials suitable for different parts of vehicle

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Automobile Engineering and Technology: (7 Hours)
Exposures to systems in a vehicle - power system: Gasoline, diesel, bio-diesel, electrical, hybrids, etc. Transmission system: clutch, gear trains, differential. Suspension, steering, breaks etc.
Controls: Clutch, gear, accelerator. Dash board displays. HVAC
Vehicle structure-Body On Frames, mononcoque.
Modern assembly (robotic) and finishing technologies
Packaging & Integrating Methodology, aerodynamics, ergonomics, Seating Systems, Trim Systems, Trim Systems, Safety & Homologatin,

UNIT-II: Model Making: (7 Hours)
'Quick and dirty prototypes' depicting the idea, Use of papers, wire, wood, POP, Exploratory and form mock-ups. Use of Polystyrene foam, Polyurethane foam, woood, metal, finished model: Vacuum Forming, Polystyrene sheet, acrylic sheets, Workshop / Studio Safety, Fabrication:

Cutting, Welding, Painting the models, Exercises and tasks to gain competency n model making that they can apply in future courses and projects.

UNIT-III: Forms, Space, Order and Sketching: (7 Hours)

Rectilinear and Curvilinear Volumes, 2 and 3D Planes, Lines in space, 2 and 3D Form transition. Exploration of form to develop imagination and insight, Use of metaphors to generate new forms. Concept of family of forms, Use of combinatrics as a method of 3D form generation, Exploration of surface textures in different materials, Form, material and process relationship. Perspectives and Object drawing, Light and Shadow, Renderings, Live sketching of people, object, animals, Exercises in studio lighting.

UNIT-III: Vehicle Ergonomics: (7 Hours)

Introduction to Ergonomics / human factors, the concept of System Design. How to look at the design issues, Use of Anthropometry in vehicle design, Biomechanics and vehicle design, Principle of automobile Chair Design, Neural Systems, Communication in Automobile system, Vehicle for the special people, Final design Assignment

UNIT V: Material and Manufacturing: (7 Hours)

Properties and usage of thermoplastics, thermosetting plastics. Process of selection and applications of plastics for Mobility Products. Design limitations in application of Plastics in Mobility, Assembly Processes and Decorative techniques for Automotive Trims. Design, Limitations and Selection of materials, Manufacturing processes and assembly techniques for Ferrous and non –ferrous metals in mobility applications.

REFERENCE BOOKS:	
1.	Powell, Dick; Design Rendering Techniques: A Guide to Drawing and Presenting Design Ideas, Publisher: North Light Books, 1996
2.	Rob Thompson; Prototyping and Low-volume Production; Thames & Hudson; United Kingdom; 29 March 2011
3.	Roberto Lucci& Paolo Or landini; Product Design Models; Van Nostrand Reinhold; New York; 1990
4.	Edwards, Betty; New Drawing on the Right Side of the Brain, Publisher; Tarher; 1 Nov. 2012
5.	Hannah, Gail Greet; Elements of Design, Princeton Architectural Press, 2013
6.	B. Peacock, Waldemar Karwowski; Automobile ergonomics Publisher: CRC; 1 edition, 1993
7.	Heinz Heisler: Advanced Vehicle Technology, Publisher: Butterworth -Heinemann, 2002.

Energy Storage Techniques

Course Code:	PE	Energy Storage Techniques	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of different types energy, storage methodology is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	To understand working of different types of electric vehicles.
CO2	To explain the battery parameters.
CO3	To understand different types of batteries.
CO4	To illustrate battery charging and modelling
CO5	To introduce novel and alternate energy sources.

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I (5 Hrs)
Energy Storage Technologies: Classification of Storage Technologies by Energy type- Thermal Energy: Heat Storage; Chemical Energy: Organic and Non- Organic; Mechanical Energy: Kinetic and Potential Energy; Electrical Energy: Electrical Potential.

UNIT-II (6 Hrs)
Energy Storage Systems in Modern Electrical Systems: Lead-acid battery, Nickel-cadmium battery, Lithium-ion battery, Sodium-sulfur battery, Nickel metal hydride battery, Fuel cells, Capacitors and Super capacitors. Solid state Batteries. Differences amongst different ESS.

UNIT-III (8Hrs)

Typical ESS and Battery Chemistry: Electrodes, Electrolytes, Collectors, Thermal management, Packaging of battery pack Lithium based batteries: Lithium manganese oxide, Lithium iron phosphate, Lithium nickel manganese cobalt oxide, Lithium nickel cobalt aluminum oxide and Lithium titanate; Silicon based Batteries, Sodium-sulfur Batteries, Proton Batteries, Graphite Dual-Ion Batteries, Salt-water Batteries and Potassium-Ion Batteries.

UNIT-IV (8Hrs)

Development cycle of Batteries: ESS sizing, Electrical, Mechanical and Thermal Design, BMS Software and Hardware development, Prototype development, System Validation, Lab Testing, Safety test and Certification. Battery Management Systems (BMS): Introduction to BMS, Objectives of the BMS: Discharging control, Charging control, State-of-Charge Determination, State-of-Health Determination, Cell Balancing; BMS topologies: Distributed Topology, Modular Topology and Centralized Topology, Firmware development, Certification, Aging.

UNIT-V (7 Hrs)

Batteries for the EV application: Performance criterion for EV batteries- Energy density, Amp hour density, Energy efficiency, Cost, Operating temperature, number of life cycles, recharge and self-discharge rates and commercial availability, some reference batteries and extension to non automotive sectors

Suggested Books:

1. Alfred Rufer, “Energy Storage systems and components”, CRC 2017

2. Press Tom Denton, “Automotive Electrical and Electronic Systems”, 5th Edition, Routledge 2018

3. Mehard Ehsani, Yiming Gao, Stefano longo and Kambiz Ebrahimi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles”, CRC 2019 Press, 3rd Edition.

4. Iqbal Husain, “Electric Fundamentals”, CRC Press. and Hybrid Vehicles: Design 2021

5. K. T. Chau, “Energy Systems for Electric and Hybrid Vehicles,” IET Transportation Series 2 2016

6. Jiuchun Jiang and Caiping Zhang, “Fundamentals and Applications of Lithium–Ion Batteries in Electric Drive Vehicles,” John Wiley & Sons 2015

Suggested References: 1. E. Karden, S. Ploumen, B. Fricke, T. Miller and K. Snyder, “Energy storage devices for future hybrid electric vehicles,” J. Power Sources, vol. 168, no. 1, pp. 2–11, 2007

Wireless Sensor Network

Course Code:	PE	Wireless Sensor Network	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Computer networking concepts
Course Outcomes: At the end of the course, students will be able to:

CO1	Identify different issues in wireless ad hoc and sensor networks.
CO2	To analyze protocols developed for ad hoc and sensor networks.
CO3	To identify and address the security threats in ad hoc and sensor networks.
CO4	Establish a Sensor network environment for different type of applications.

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: MAC & TCP IN AD HOC NETWORKS **(7 Hours)**
Fundamentals of WLANs, IEEE 802.11 Architecture, Self-configuration and Auto configuration, Issues in Ad-Hoc Wireless Networks, MAC Protocols for Ad-Hoc Wireless Networks, Contention Based Protocols-TCP over Ad-Hoc networks, TCP protocol overview-TCP and MANETs, solutions for TCP over Ad-Hoc Networks.

UNIT-II: ROUTING IN AD HOC NETWORKS (7 Hours)
Routing in Ad-Hoc Networks, Introduction, Topology based versus Position based Approaches, Proactive, Reactive, Hybrid Routing Approach, Principles and issues ,Location services ,DREAM ,Quorums based location service, Grid–Forwarding strategies, Greedy packet forwarding ,Restricted directional flooding, Hierarchical Routing, Issues and Challenges in providing QoS.

UNIT-III: MAC, ROUTING & QOS IN WIRELESS SENSOR NETWORKS (7 Hours)

Introduction, Architecture, Single node architecture, Sensor network design considerations ,Energy Efficient Design principles for WSNs, Protocols for WSN, Physical Layer : Transceiver Design considerations, MAC Layer Protocols ,IEEE802.15.4 Zigbee, Link Layer and Error Control issues-Routing Protocols, Mobile Nodes and Mobile Robots, Data Centric & Contention Based Networking ,Transport Protocols & QOS, Congestion Control issues ,Application Layer support.

UNIT-IV: -SENSOR MANAGEMENT (7 Hours)

Sensor Management, Topology Control Protocols and Sensing Mode Selection Protocols, Time synchronization, Localization and positioning, Operating systems and Sensor Network programming, Sensor Network Simulators.

UNIT-V: -SECURITY IN AD HOC AND SENSOR NETWORKS (7 Hours)

Security in Ad-Hoc and Sensor networks, Key Distribution and Management, Software based Anti-tamper techniques, water marking techniques, Defence against routing attacks, Secure Adhoc routing protocols, Broadcast authentication WSN protocols, TESLA, Biba, Sensor Network Security Protocols, SPINS.

REFERENCE BOOKS:	
1.	Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006.
2.	Carlos De Morais Cordeiro, Dharma Prakash Agrawal “Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition), World Scientific Publishing, 2011.
3.	C.Siva Ram,Murthy and B.S.Manoj, “Ad Hoc Wireless Networks–Architectures and Protocols”, Pearson Education, 2004.
4.	C.K.Toh, “Ad Hoc Mobile Wireless Networks”, Pearson Education, 2002.
5.	Erdal Çayırcı , Chunming Rong, “Security in Wireless Ad Hoc and Sensor Networks”, John Wiley and Sons, 2009.

Artificial intelligence in EV

Course Code:	PEC	Artificial intelligence in EV	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Explain the fundamental concepts of AI and its relevance to EV
CO2	Learn how machine learning can be applied to battery management
CO3	Understand the application of AI in optimizing powertrain performance
CO4	Learn about AI applications in autonomous driving and advanced driver assistance systems (ADAS)
CO5	Analyze the impact of AI on vehicle communication and security

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Introduction to Artificial Intelligence in EVs: **(7 Hours)**
Overview of AI, Role of AI in EVs, AI System Architecture in EVs, AI Tools and Frameworks, Case Studies: Examples of AI applications in current EVs, Impact and benefits of AI in EV technology

Unit-II: Machine Learning for Battery Management Systems: **(7 Hours)**
Introduction to Machine Learning, State of Charge (SoC) Estimation, State of Health (SoH) monitoring, Predictive Maintenance

Unit-III: AI for Powertrain Optimization **(7 Hours)**
Powertrain Components and AI, Energy Management, Motor Control, Predictive Analytics, Simulation and Testing.

Unit-IV: Autonomous Driving and ADAS **(7 Hours)**
Overview of Autonomous Driving, Perception Algorithms, Decision Making, Control Systems, Simulation and Testing.
Unit-V: AI for Vehicle Connectivity and Cybersecurity: **(7 Hours)**
Vehicle Connectivity, Telematics and IoT, Cybersecurity Threats, AI-based Security Solutions.

Reference Books

1. **"Artificial Intelligence: A Modern Approach"** by Stuart Russell and Peter Norvig
2. **"Machine Learning Yearning"** by Andrew Ng
3. **"Deep Learning"** by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
4. **"Autonomous Driving: How the Driverless Revolution Will Change the World"** by Andreas Herrmann, Walter Brenner, and Rupert Stadler
5. **"Connected Vehicles: Intelligent Transportation Systems"** by Radovan Miucic

Constitution of India

Code:	Constitution of India	AC	0-0-0	Audit Course
Exam Scheme				
Teaching Scheme: 2 Lectures / Week	Continuous Assessment 50 Marks		Total 50 Marks	

Course Outcomes:

At the end of the course the students will
CO1: Understand the key aspects of the Indian Constitution.
CO2: Comprehend the structure and philosophy of the Constitution
CO3: Understand the power and functions of various constitutional offices and institutions.
CO4: Realise the significance of the constitution and appreciate the role of constitution and citizen oriented measures in a democracy.

Mapping of COs with POs:

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

Module.1 Introduction (5 Lectures)
Constitution' meaning of the term, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive, Principles of State Policy
Module.2 Union Government and its Administration (5 Lectures)
Structure of the Indian Union: Federalism, Centre- State, relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha
Module.3 State Government and its Administration (4 Lectures)
Governor: Role and Position, CM and Council of ministers, State Secretariat: Organisation, Structure and Functions
Module.4 Local Administration (5 Lectures)
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role, Block level:

Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Module.5 Election Commission (5 Lectures)

Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

TEXT/REFERENCE BOOKS:

1. Sastry, T. S. N., (2005). India and Human rights: Reflections, Concept Publishing Company India (P Ltd.),

2. Nirmal, C.J., (1999). Human Rights in India: Historical, Social and Political Perspectives (Law in India), Oxford India.

Semester-II

Electrical Drives for EV

Course Code:	PCC	Electrical Drives for EV	3-1-0	4 Credit

Teaching Scheme	Examination Scheme
Lecture:3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Basic Knowledge on Electrical Machines, Power Electronics required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Interpret the significance of speed- torque characteristics of electrical drives and methods to modify the characteristics.
CO2	Evaluate the performance of AC Voltage Controller fed induction motor drive
CO3	Implement VSI fed v/f controlled AC motor drive
CO4	Analyze the concept of Field Oriented Control of an induction motor.
CO5	Determine the speed control methods of synchronous motor based on application

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Dynamics of Electrical Drives: **(6 Hours)**
Basics of Power Electronic Drive system and components. Different types of loads, shaft-load coupling systems. Stability of power electronic drive.

UNIT-II: DC Motor Drives-I: **(8 Hours)**
Conventional methods of D.C. motor speed control, single phase and three phase converter fed D.C motor drive. Four quadrant operations using dual converter fed DC motor drives.

UNIT-III: DC Motor Drives-II: **(7 Hours)**
Chopper fed drives, input filter design. Braking and speed reversal of DC motor drives using choppers, Multiphase choppers.

UNIT-IV: Induction Motor Drives: **(10 Hours)**
Conventional methods of induction motor speed control. Solid state controllers for Stator voltage control, soft starting of induction motors, Rotor side speed control of wound rotor induction motors. Voltage source and Current source inverter fed induction motor drives – Principle of Vector Control.

UNIT-V: Synchronous Motor Drives: **(10 Hours)**
Speed control of synchronous motors, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives, Field Oriented Control of PMSM. Use of DSP for Control of Drives. Use of PLC for Control of Drives. Comparison of DSP based and PLC based drives and its future Applications.

REFERENCE BOOKS:	
1.	G. K. Dubey – Power Semiconductor Controlled drives, Prentice-Hall, Eaglewood cliffs.
2.	Bimal K Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia 2002
3.	P. Vas – Vector control of ac machines, Clarandon Press, Oxford
4.	Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw Hill, 1994.
5.	Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, Delhi, 2001.

Automotive HVAC and Thermal Management of EV systems

Course Code:	PCC	Automotive HVAC and Thermal Management of EV systems	3-1-0	4 Credit

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of applied thermodynamics, heat transfer and refrigeration and air conditioning is required.

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

CO1	Describe different types of temperature dependent failures in electronics systems.
CO2	Describe series and parallel thermal layers and thermal resistance in PCB.
CO3	Use suitable fins and heat sinks for a given electronic application.
CO4	Compare different advanced cooling technologies.
CO5	Analyse thermal specifications of microelectronic package and parameters affecting thermal

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Introduction to thermal management of Electronics (7 Hours)
Semiconductor Technology Trends, Temperature Dependent Failures Temperature-Dependent Electrical Failures Importance of Heat Transfer in Electronics, Thermal Design Process.

UNIT-II: Thermal Resistance Network: (8 Hours)
Thermal Resistance Concept, Series Thermal Layers, Parallel Thermal Layers General Resistance Network, Thermal Contact Resistance, Interface Materials, Spreading Thermal Resistance Thermal Resistance of Printed Circuit Boards (PCBs).

UNIT-III: Fins and Heat Sinks (8 Hours)
Fin Equation, Infinitely Long Fin, Adiabatic Fin Tip Convection and Radiation from Fin Tip, Constant Temperature Fin Tip Fin Thermal Resistance, Effectiveness, and Efficiency with Variable

Cross Sections. Heat Sink Thermal Resistance, Effectiveness, and Efficiency, Heat Sink Manufacturing Processes.

UNIT-IV: Advanced Cooling Technologies: (8 Hours)

Pipes, Capillary Limit, Boiling Limit. Sonic Limit, Entrainment Limit, Other Heat Pipe Performance Limits, Heat Pipe Applications in Electronic Cooling, Thermosyphons, Liquid Cooling.

UNIT-V: Thermal Specification of Microelectronic Packages: (8 Hours)

Importance of Packaging, Packaging Types, Specifications of Microelectronic Packages, Junction-to-Air Thermal Resistance, Junction-to-Case and Junction-to-Board, Thermal Resistances, Package Thermal Characterization Parameters, Parameters Affecting Thermal Characteristics of a Package.

REFERENCE BOOKS:	
1.	Younes Shabany," Heat Transfer: Thermal Management of Electronics" 2010 , CRC Press.
2.	Jerry Sergent, Al Krum, "Thermal Management Handbook: For Electronic Assemblies Hardcover", 1998, Mc Graw- Hill.
3.	"Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK
4.	T. Yomi Obidi**, "**Thermal Management in Automotive applications", 2015, SAE International.

Electric and Hybrid Vehicles

Course Code:		**Course Type:**	**PCC**
Teaching Hours/Week (L-T-P):	**3-1-0**	**Credits:**	**04**

Course Outcomes:

1. Identify EV concepts, EV configurations and various EV parameters for better understanding of the EV technology.
2. Analyse the EV propulsion system and electric motors for vehicular applications & power electronics converters required for their control.
3. Analyse DC motor & induction motor drives and discuss control methods.
4. Elaborate various hybrid electric vehicle configurations and explain the power flow control in all HEV configurations
5. Identify different energy sources used in EV and analyse the various methods used in charging these energy sources

Mapping of course outcomes with program outcomes

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

UNIT-I

Introduction to EV & HEV **07 Hours**

Introduction:

Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.

EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drive, In-wheel drives

EV Parameters: Weight, size, force, energy & performance parameters.

UNIT-II

EV Propulsion- Electric Motor: **07 Hours**

Choice of electric propulsion system, block diagram of EV propulsion system, concept of EV Motors, single motor and multi-motor configurations, fixed & variable geared transmission, In wheel motor configuration, classification of EV motors, Electric motors used in current vehicle applications, Recent EV Motors,

Comparison of Electirc Motors for EV applications

Required Power Electronics & Control: **07 Hours**

Comparison of EV power devices, introduction to power electronics converter, four quadrant DC chopper, three-phase full bridge voltage-fed inverter, soft-switching EV converters, comparison of hard-switching and soft-switching converter, three-phase voltage-fed resonance dc link inverter, Basics of Microcontroller & Control Strategies

UNIT-III

EV Motor Drives **07 Hours**

DC Motor: Type of wound-field DC Motor, Torque speed characteristics

DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor

Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control

UNIT-IV

HEV (Hybrid Electric Vehicle): **07 Hours**

Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow

control in all HEV configurations, Examples of HEV system performance

UNIT-V

Energy Sources & Charging: **07 Hours**

Different Batteries and Ultra-capacitors, Battery characteristics (Discharging &Charging) Battery Chargers: Conductive (Basic charger circuits, microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication Methods Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

REFERENCE BOOKS:	
1.	C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001
2.	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
4.	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

HVAC & Thermal Management Lab

Course Code:	PCC Lab	HVAC & Thermal management Lab	1-0-0	1 Credit

Teaching Scheme	Examination Scheme
Lecture: 2 Hrs/week	Continuous Assessment: 25 Marks End Semester Exam: 25 Marks

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

CO1	Understand the principles of HVAC and thermal management systems in EVs.
CO2	Gain practical experience in designing, testing, and optimizing HVAC systems.
CO3	Learn to analyze the thermal performance of various EV components.
CO4	Develop skills to troubleshoot and improve HVAC and thermal management systems.

Mapping of course outcomes with program outcomes

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

All Experiments from the list:

1. To study the basic components and operation of HVAC systems in electric vehicles.
2. Analyze the thermal behavior of EV batteries and implement cooling strategies.
3. Study the heat generation and dissipation in electric motors
4. Calculate the heating and cooling loads for the EV cabin
5. Design and operation of heat pump systems in EVs.
6. simulation software to model and analyze HVAC systems (MATLAB)
7. Study the thermal management requirements of power electronics in EVs.
8. Evaluate the air quality and ventilation efficiency in the EV cabin.
9. Test the performance of radiators used in EV thermal management systems.

Seminar-I

Course Code:	PCC Lab	Seminar-I	0-0-2	1 Credit

Teaching Scheme	Examination Scheme
Practical : 2 Hrs/week	Continuous Assessment: 25 Marks End Semester Exam: 25 Marks

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

CO1	Develop research and analytical skills by exploring current topics in EV technology.
CO2	Enhance presentation and communication skills through seminars and discussions.
CO3	Encourage independent learning and critical evaluation of research papers and technical reports.
CO4	Foster collaboration and knowledge sharing among peers and faculty.

Mapping of course outcomes with program outcomes

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

Seminar-I is designed to provide M.Tech students with the opportunity to explore and present on recent advancements, research findings, and emerging trends in the field of Electric Vehicle (EV) Technology. This course emphasizes the development of research skills, critical thinking, and effective communication.

Professional Elective-III
Smart Grid and Advanced charging Infrastructure

Course Code:		**Course Type:**	**PEC**
Teaching Hours/Week (L: T: P):	**3:0:0**	**Credits:**	**03**

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

1. Describe Plug in Electric Vehicle technologies and wire less power transfer for electric vehicles.
2. Illustrate the cyber security of Plug in Electric Vehicle technologies in Smart Grid
3. Analyse the impact of plug in electric vehicles on power system
4. Describe the PEV Load and Its Impact on Static Voltage Stability
5. Describe the impact of large-scale EV charging loads to grid frequency.

Mapping of course outcomes with program outcomes

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

UNIT-I
Overview of Plug-in Electric Vehicle Technologies **07 Hours**
PEV Technologies, PEV Systems, impacts, Smart Charging Infrastructure, Integration of PEVs to Electric Grid Promotional Programs on PEVs

UNIT-II
Wireless Power Transfer (WPT) for Electric Vehicles (EVs) **07 Hours**
Wireless Energy Transfer Methods, Inductive Coupling Versus Magnetic Resonance Coupling, Modelling the WPT System, WPT for EV Charging, Stationary WPT for EV Charging, Dynamic WPT for EV Charging

UNIT-III
Cyber Security of Plug-in Electric Vehicles in Smart Grids: Application of Intrusion **07 Hours**
Detection Methods, Smart Grids with PEVs, Communication Infrastructure, Communication Standards, Cyber Security Challenges, Data Attacks and Intrusions in PEV Communications, Intrusion Detection Methods, Application to the Detection of Malicious PEV Penetration Level

UNIT-IV
Impact Evaluation of Plug-in Electric Vehicles on Power System. **07 Hours**

Probabilistic PEV Charging Demand, Fast Charging Points, Probabilistic Arrivals, Probabilistic PEV Charging Demand, Probabilistic Grid Impact of Fast Chargers.

PEV Load and Its Impact on Static Voltage Stability

Modeling of PEV Charging Load, Introduction to Power System Load Characteristics, Modeling of the PEV Charging Load, Effects of Charger Resistances on Load Model Parameters, Newton Raphson Power Flow with PEV Load, Impact of PEV Charging Load on System Static Voltage Stability, Voltage Stability Theory, Static Voltage Stability Analysis, Mitigating PEV Charging Impacts through Voltage Control, Mitigating PEV Charging
Impact through Proper Planning

UNIT-V

The Response of Large-Scale EV Charging Loads to Frequency **07 Hours**

Introduction Characteristics of EV Charging Loads, Current Related Research of EVs on FR , EVs' Advantages in FR ,The Current Related Research of FR Based on the Coordination Among EVs, AGC, BESSs Properties of FR Resources ,Traditional FR Resources ,Large-Scale Energy Storage Devices ,EV/BESS FR Resource, Coordinated Control Strategy for EVs/BESSs ,Coordination Principle ,Implementation Method for Coordinated FR, Case Study and Results , Simulation Model and Parameters, Simulations of Power System FR The Asynchronous Response of Small-Scale Charging Facilities to Grid Frequency, Formulation of the Proposed, Control Method . Demonstration of coordination, Demonstration of equality.

Course Outcomes Mapping with Program Outcomes

REFERENCE BOOKS:	
1.	Sumedha Rajakaruna, FarhadShahnia and Arindam Ghosh, "Plug In Electric Vehicles in Smart Grids-Integration Techniques", Springer Science + Business Media Singapore Pte Ltd., 2015.
2.	Canbing Li, Yijia Cao, YonghongKuang and Bin Zhou, "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid", Springer-Verlag Berlin Heidelberg, 2016.
3.	Qiuwei Wu, "Grid Integration Of Electric Vehicles In Open Electricity Markets", John Wiley & Sons, Ltd, 2013.

Design, Testing and certification of EV

Course Code:	PEC	Design, Testing and certification of EV	3-0-0	3 credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Illustrate different standards related construction and safety in electric vehicles
CO2	Describe central motor vehicles rules (CMVR) type of standards for electric and hybrid electric vehicles.
CO3	Describe CMVR types of standards for retro fitment of existing IC engine driven vehicles.
CO4	Illustrate safety standards of traction batteries.
CO5	Describe government policies like national electronic mobility plan related to EVs

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I: Introduction: (7 Hours)
Electric power train vehicles-construction and functional safety requirements measurement of electrical energy consumption, Method of measuring the range, Measurement of net power and the maximum 30
minute power, CMVR type approval for electric power train vehicles, ISO 26262.

UNIT-II: Charger Standard: (7 Hours)
Electric Vehicle Conductive AC Charging System, Electric Vehicle Conductive DC Charging System.

HEV Standard: CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW > 3500 kg

UNIT-III: Retro fitment Standards: (7 Hours)

CMVR Type Approval of Hybrid Electric System Intended for Retro fitment on Vehicles of M and N Category having GVW <= 3500 kg and GVW > 3500 kg. CMVR Type Approval of Electric Propulsion Kit Intended for Conversion of Vehicles for Pure Electric Operation.

UNIT-IV: Safety Requirement of Traction Battery: (7 Hours)

Introduction to Vehicle safety standards, Rules and Regulations, Environmental impurities and safety requirements, Battery Operated Vehicles -Safety Requirements of Traction Batteries, Automotive safety
components certification by various organizations (ARAI, SIAM, SAE, ASME, FMVSS).

UNIT-V: Government Policies: (7 Hours)

National Electric Mobility Mission Plan 2020 (NEMMP2020), Faster Adoption and Manufacture of (Hybrid and Electric Vehicles) – FAME, Niti Aayog Report on Transforming Mobility

REFERENCE BOOKS:	
1.	Automotive Industry Standards, India, 2015-2016
Other References	
1.	https://araiindia.com
2.	*https://emobility.araiindia.com*
3.	*https://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf*
4.	https://niti.gov.in/content/national-mission-transformative-mobility-and-battery-storage
5.	https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf

Advanced Materials in Design

Course Code:	PEC	Advanced materials in design	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of engineering materials and metallurgy is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the properties and applications of advanced materials used in electric vehicle components.
CO2	Analyze the performance and durability of materials under various operating conditions in electric vehicles.
CO3	Evaluate the environmental impact and sustainability of using advanced materials in electric vehicle manufacturing.
CO4	Apply knowledge of material science to innovate and improve electric vehicle design and efficiency.
CO5	Develop skills in selecting appropriate materials for specific electric vehicle applications, considering factors such as weight, cost, and performance

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Engineering Plastics: **(7 Hours)**
Properties and use of thermoplastics, thermosetting plastics. Process of selection and applications of plastics for engineering products. Design Limitations and specific advantages of plastic modelling processes.

Unit-II: Rubber: **(7 Hours)**

Properties and use of rubber and glass. Properties of alternative materials like wood, bamboo, cane, leather,cloth, jute etc..and their use from craft and industry perspectives.

Unit-III: Material for body **(7 Hours)**

Assembly and Decorative techniques for plastic product Manufacturing processes and assembly techniques for Ferrous and non-ferrous metals.

Unit-IV: Concepts of structure and costing. **(7 Hours)**

Significance of form in structural strength of products. Influence of materials and processes on product aesthetics. Industrial finishes for plastic, wood and metals.

Unit-V: Composite Materials: **(7 Hours)**

Types, properties, Selection, merit and limitations over conventional materials.

REFERENCE BOOKS:	
1.	Beadle, John D : Product treatment and finishes, Macmillan, London 1971
2.	Beck R. D.: Plastic Product Design, Van Nostrand Reinhold Co., New York, 1980
3.	Cleminshaw D., Design in Plastics, Rockport Publishers Inc. (22 February 1994)
4.	Garratt J.: Design and Technology, Cambridge University Press, UK, 2004
5.	https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf

IoT Technology in EV

Course Code:	PEC	IoT Technology in EV	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

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

Mapping of course outcomes with program outcomes

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

Course Contents:

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

Unit-II: IoT for Battery Management and Monitoring: **(7 Hours)**
Architecture and components of IoT-enabled BMS, Data acquisition from battery cells and modules, Techniques for real-time monitoring of battery parameters (voltage, current,

temperature),Using IoT sensors and gateways for data collection, Predictive Analytics, Remote Diagnostics.

Unit-III: IoT for Powertrain and Energy Management **(7 Hours)**

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

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

Common security threats in IoT-enabled EVs, Vulnerabilities in IoT components and communication

Encryption techniques for secure data transmission, Intrusion detection and prevention systems, Data acquisition, storage, and processing in IoT systems, Cloud and edge computing for IoT data management, Privacy and Compliance

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

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

Reference Books

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

Charging Infrastructure

Course Code:	PEC	Charging Infrastructure	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of Batteries.
Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various types of charging infrastructure, including residential, public, and fast-charging stations, and their respective technologies.
CO2	Analyze the electrical grid requirements and impacts of integrating widespread electric vehicle charging infrastructure.
CO3	Evaluate the design, installation, and maintenance considerations for efficient and reliable EV charging systems.
CO4	Develop strategies for optimizing the placement and distribution of charging stations to maximize accessibility and minimize congestion.
CO5	Apply knowledge of regulatory standards, safety protocols, and interoperability requirements to the deployment and management of EV charging infrastructure.

Mapping of course outcomes with program outcomes

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

Course Contents:

UNIT-I (8 Hrs)
Introduction: introduction to EV systems, EV benefits, battery charging modes, types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges.
Charger Classification and standards: classification based on charging levels (region-wise), modes, plug types, standards related to: connectors, communication, supply equipments, EMI/EMC

UNIT-II (8 Hrs)

AC-DC Converter: types of AC-DC converters; working principles, modulation, design, and closed loop control of power factor correction converters (PFC): Boost type PFC, Totem-pole PFC, active front-end converter, three-phase PFCs; working principles, modulation, design, and closed loop control of single-stage AC-DC converters; G2V, V2X operations

UNIT-III (8 Hrs)

DC-DC Converter: Types of DC-DC converter used for EV chargers; working principles, modulation, design, modelling and closed loop control of dual active bridge, LLC converter, high frequency magnetics, soft-switching criteria

UNIT-IV (6 Hrs)

Protocols and communication: Open charge point protocol (OCPP), Open System Interconnection-Layer-Model (OSI), adapted PWM signal based low level communication, PLC based high level communication, CAN communication, testing methodology for EV battery chargers and EVSE .

UNIT-V (5Hrs)

EMI/EMC considerations: sources of EMI, differential mode noise, common mode noise, LISN, measuring of EMI/EMC spectrum, design of DM filters,CM filters

Case Study: Case-studies on Delta, Hella on-board chargers, latest EV reports released by Government of India

Suggested Books:

1. Tom Denton, "Automotive Electrical and Electronic Systems", 5th Edition, Routledge 2018.
2. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press. 2021
3. Robert W. Erickson, and Dragan Maksimovic "Fundamentals of Power Electronics", 3rd , Springer 2020
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India. 2012
5. Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design", 3rd Ed., Wiley India. 2008
6. Christoph Marscholik and Peter Subke, "Road Vehicles - Diagnostic Communication" University Science Press 2009
7. Wolfhard Lawrenz, "CAN System Engineering: From Theory to Practical Applications", Springer. 2013

Professional Elective-IV

Energy Management

Course Code:	PCC	Energy Management	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites: Knowledge of applied mechanics, automobile engineering is required.
Course Outcomes: At the end of the course, students will be able to:

CO1	Analyse energy scenario, audit and management.
CO2	Apply energy conservation policy, regulations in industrial practices.
CO3	Evaluate energy economics.
CO4	Identify opportunities for rational use of energy.
CO5	Analyze electrical systems for energy conservation.
CO6	Analyze the thermal systems for energy efficiency.

Mapping of course outcomes with program outcomes

PO→ CO ↓	1	2	3	4	5	6	7	8	9	10	11	12
CO1	3	3									3	2
CO2	3		3								3	2
CO3	3	2	3								3	2
CO4	3										3	2
CO5	3	3									3	2
CO6	3	3									3	2

Course Contents:

UNIT-I: Energy Scenario: (7 Hours)
Introduction to energy & power scenario of world, National Energy consumption data and environmental aspects associated with energy utilization; Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing.

UNIT-II: Energy Conservation Act 2001 and related policies: (7 Hours)
Energy conservation Act 2001 and its features, notifications under the Act, Schemes of Bureau of Energy Efficiency (BEE) including designated consumers, State Designated Agencies, ECBC code for Building Construction.

UNIT-III: Financial Management: (7 Hours)

Energy Economics- discount period, payback period, internal rate of return, net present value; Life Cycle costing- ESCO concept.

UNIT-IV: Energy Monitoring and Targeting: (5 Hours)

Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques – energy consumption, production, cumulative sum of differences (CUSUM).

UNIT-V: Energy Conservation in Electrical Utilities: (8 Hours)

Components of EB billing, HT and LT supply, transformers, cable sizing; Concept of capacitors, power factor improvement, harmonics; Electric motors- motor efficiency computation, energy efficient motors; Illumination- Lux, Lumens, types of lighting, efficacy, LED lighting and scope of energy conservation in lighting.

UNIT-VI: Energy Efficiency in Thermal Utilities and systems: (13 Hours)

Thermal systems, Boilers, Furnaces, Heat exchangers and Thermic Fluid heaters- efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories. Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration& Air Conditioning systems, Cooling Towers, DG sets.

REFERENCE BOOKS:	
1.	Witte L.C., Schmidt P.S. and Brown D.R., “Industrial Energy Management and Utilization”, Hemisphere Publ., Washington, 1988.
2.	Callaghan P.W., “Design and Management for Energy Conservation”, Pergamum Press, Oxford
3.	Murphy W.R. and McKay G., “Energy Management”, Butterworth’s, London, 1987.
4.	Bureau of Energy Efficiency, “Energy Manager Training Manual”, Reference book No:1 to 4
5.	Dale R Patrick, Stephen W Fardo, “Energy Conservation Guidebook”, 2nd Edition, CRC Press.
6.	Shobh Nath Singh, "Non-Conventional Energy Resources", Pearson Education India; First edition (2015).

Automotive Safety

Course Code:	PEC	Automotive Safety	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Comprehend the algorithms of cryptography for data and network security
CO2	Analyze the importance of key security and customization challenges for embedded security
CO3	Explain the importance of Protection of IP in cloud connected network
CO4	Describe the importance of message authentication and security challenges and solutions for automotive network.
CO5	Analyze the importance of firmware resiliency in automotive applications.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Cryptography Introduction: **(7 Hours)**
Introduction to cryptography, Classical Cryptosystem, Block Cipher Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher. Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Knapsack Cryptosystem, RSA Cryptosystem.

Unit-II: Embedded Security: Introduction: **(7 Hours)**
Authentication, Integrity and Confidentiality, Properties of secure system Security elements (JIL), importance of keys in security, customization challenges, distribution of keys, tools and examples.(cryptoAuthlib).

Unit-III: Protecting IP in cloud connected world: (7 Hours)
Protection of IP, CODE isolation, encryption, hardware security, trustonic expertise tool for IP protection.

Unit-IV: Automotive Network security: (7 Hours)
Motivation for automotive network security, Automotive security, message authentication, Automotive security IC attributes, security challenges.

Unit-V: Firmware Resiliency in Automotive application: (7 Hours)
Automotive growth drivers, Firmware Vulnerabilities in automotive, Simplified protection, Automotive Platform firmware protection (secure boot controller). Firmware Vulnerabilities in data centre.

TEXTBOOKS:	
1.	Wiiliam Stallings, "Cryptography and Network security Principles and practices ", 4th Edition, prentice hall, November 16,2015.
E-Resources:	
1.	https://onlinecourses.nptel.ac.in/noc21_cs16/preview
2.	https://www.microchip.com/en-us/solutions/embedded-security
3.	https://vimeo.com/371395354
4.	https://vimeo.com/391579350?aliId=eyJpIjoiK1V6Z1M0VTRIdVR3SmlPaCIsInQiOiJMbWxYM1pr T2Z QNXhTemVoWEFkRVRBPT0ifQ%253D%253D
5.	https://vimeo.com/400991351?aliId=eyJpIjoiN2I1Z2N2c0pBNUlodmFsZyIsInQiOiJ5bFlzT3lVUnVk RjN RSlpXd0xJNmRBPT0ifQ%253D%253D
6.	SHIELDS UP! Webinar #27: Platform Firmware Resiliency in Automotive Applications (2822370) (on24.com)
7.	https://page.microchip.com/FY21Q2-ShieldsUP-HardGates_LP-ShieldsUp-Webinar3.html
8.	SHIELDS UP! Webinar #33: Data Center Security Solutions (2977322) (on24.com)

Life Cycle Analysis of EV

Course Code:	PEC	Life cycle analysis of EV	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Identify the stages and methodologies of LCA
CO2	Apply best practices in LCI data collection and assessment
CO3	Interpret and use LCIA results for informed decision making
CO4	Implement strategies for life cycle management and improvement in EVs
CO5	Analyze and compare the environmental impacts of EVs and conventional vehicles

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Introduction to Life Cycle Analysis (LCA) **(7 Hours)**
Definition and purpose of LCA, Role of LCA in assessing environmental impacts, LCA Methodology, Types of LCA,

Unit-II: Life Cycle Inventory (LCI) for Electric Vehicles **(7 Hours)**
Definition and purpose of Life Cycle Inventory, Key components of LCI, Primary vs. secondary data
Data sources and quality assessment, Material and Energy Inputs, Emissions and Waste Outputs.

Unit-III: Life Cycle Impact Assessment (LCIA) for EVs **(7 Hours)**
Overview of LCIA, Common impact categories (global warming potential, acidification, eutrophication, etc.), Relevance of impact categories to EVs, Methods for assessing environmental impacts, Impact characterization models (TRACI, CML, etc.), Techniques for comparing and

aggregating impact results, Importance of normalization and weighting in LCIA

Unit-IV: Life Cycle Management and Improvement for EVs (7 Hours)

Definition and principles of life cycle management, Role of LCA in life cycle management, Strategies for designing sustainable EVs, Incorporating LCA in the design phase, Methods for reducing environmental impacts across the EV life cycle, Examples of impact reduction in materials, manufacturing, and usage, Policy and Regulation.

Unit-V: Case Studies and Applications of LCA in EVs (7 Hours)

Detailed analysis of LCA studies for different types of EVs (BEVs, PHEVs, HEVs), Comparative LCA of EVs and conventional vehicles, LCA of different battery chemistries (Li-ion, solid-state, etc.),Impact of battery manufacturing, usage, and recycling, LCA of EV charging infrastructure, Impact of different charging methods and energy sources, Emerging trends in LCA of EVs, Innovations in EV design and manufacturing for sustainability.

Reference Books

1. **"Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products"** by Mary Ann Curran
2. **"Environmental Life Cycle Assessment"** by Olivier Jolliet, Myriam Saadé-Sbeih, Shanna Shaked, Alexandre Jolliet, and Pierre Crettaz
3. **"Life Cycle Assessment: Principles and Practice"** by Scientific Applications International Corporation (SAIC)
4. **"Sustainable Automotive Technologies 2014"** by Ingemar Denbratt, Fredrik Larsson, and Bengt Johannson
5. **"Electric Vehicle Technology Explained"** by James Larminie and John Lowry

Computational techniques and optimization

Course Code:	PEC	Computational techniques and optimization	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Implement optimization techniques for engineering applications
CO2	Use simulation tools to analyze and optimize EV performance
CO3	Conduct CFD simulations for studying aerodynamics in electric vehicles
CO4	Implement machine learning techniques for optimization and control in EV systems
CO5	Evaluate the economic and environmental impacts of optimized EV solutions

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Fundamentals of Computational Techniques **(7 Hours)**
Definition and scope of computational methods, Historical development and applications in engineering, Overview of numerical techniques (root finding, interpolation, integration), Finite difference, finite element, and finite volume methods

Unit-II: Modeling and Simulation Techniques **(7 Hours)**
Mathematical modeling and simulation in engineering, Use of computational tools (MATLAB, Python, etc.) in modelling, Sources of errors in numerical computations, Techniques for error estimation and reduction

Unit-III: Computational Fluid Dynamics (CFD) in Electric Vehicles (7 Hours)

Governing Equations, Turbulence modelling techniques (LES, RANS, etc.), Pre-processing, solving, and post-processing stages, Grid generation and meshing techniques, Aerodynamic analysis and optimization of EV designs, Impact of aerodynamics on EV range and efficiency

Unit-IV: Machine Learning Applications in Electric Vehicles (7 Hours)

Definition and scope of machine learning, Types of machine learning algorithms (supervised, unsupervised, reinforcement learning), Machine Learning Techniques-Regression, classification, and clustering algorithms, Neural networks and deep learning for EV applications, Predictive modelling for battery performance and vehicle range estimation, Machine learning in autonomous driving and advanced driver assistance systems (ADAS)

Unit-V: Optimization of Electric Vehicle Systems (7 Hours)

Definition and scope of optimization, Types of optimization problems (linear, nonlinear, constrained, unconstrained), Optimization Algorithms, Multi-Objective Optimization Battery and Energy Management Optimization, Powertrain Optimization, Charging Infrastructure Optimization, Lifecycle Cost Optimization.

Reference Books

1. "Numerical Methods for Engineers" by Steven C. Chapra and Raymond P. Canale
2. "Introduction to Optimization" by Edwin K. P. Chong and Stanislaw H. Zak
3. "Computational Fluid Dynamics: Principles and Applications" by Jiri Blazek
4. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy
5. "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain

Traffic engineering & Intelligent transportation

Course Code:	PEC	Traffic engineering & Intelligent transportation	3-0-0	3 Credits

Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

Pre-Requisites:

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

CO1	Analyze traffic flow characteristics and relationships
CO2	Apply theoretical models to understand traffic flow dynamics
CO3	Evaluate the impacts of ITS on traffic systems
CO4	Apply data analytics for traffic prediction and management
CO5	Evaluate the impact of transportation policies on sustainability and resilience

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I: Fundamentals of Traffic Engineering **(7 Hours)**

Definition and scope of traffic engineering, Historical development and future trends, Fundamental traffic flow parameters (flow, speed, density), Relationships between traffic flow parameters, Traffic signs, signals, and markings, Design and application of traffic control devices, Methods for traffic data collection and analysis, Traffic volume, speed, and travel time studies

Unit-II: Traffic Flow Theory and Modeling **(7 Hours)**

Macroscopic and microscopic traffic flow models, Car-following, lane-changing, and gap acceptance models, Fundamental diagrams of traffic flow, Traffic stream parameters and their estimation, Overview of traffic simulation tools (VISSIM, AIMSUN, SUMO), Building and validating traffic simulation models, Capacity Analysis.

Unit-III: Intelligent Transportation Systems (ITS) **(7 Hours)**
Definition and goals of ITS, Evolution and future trends in ITS, ITS Architecture and Standards, Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS).

Unit-IV: Smart Mobility and Connected Vehicles **(7 Hours)**
Definition and elements of smart mobility, Smart city initiatives and mobility solutions, Vehicle-to-Everything (V2X) communication, Applications of connected vehicle technology, Autonomous Vehicles, Big data and analytics in transportation, Using data for traffic prediction and management.

Unit-V: Sustainable and Resilient Transportation Systems **(7 Hours)**
Principles of sustainability in transportation, Strategies for reducing transportation-related emissions, Definition and importance of resilience in transportation, Strategies for enhancing transportation system resilience, Transportation Planning for Sustainability, Climate Change and Transportation.

Reference Books

1. **"Traffic Engineering"** by Roger P. Roess, Elena S. Prassas, and William R. McShane
2. **"Highway Traffic Analysis and Design"** by R.J. Salter and N.B. Hounsell
3. **"Fundamentals of Traffic Engineering"** by Ricardo G. Sigua
4. **"Intelligent Transport Systems: Technologies and Applications"** by Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, and Ignacio Julio García Zuazola
5. **"Smart Cities: Foundations, Principles, and Applications"** by Houbing Song, Ravi Srinivasan, Tamim Sookoor, and Sabina Jeschke.

English for Research Paper Writing

Code:	English for Research Paper Writing	AC	2-0-0	Audit Course
Exam Scheme				
	Continuous Assessment 50 Marks		Total 50 Marks	

Objectives:

After Completing this course, students are able

Outcomes:

CO1	Develop proficiency in academic writing, including structure, style, and language, tailored to the requirements of technical research papers in electric vehicle technology.
CO2	Understand and apply the principles of effective research paper organization, including abstract, introduction, methodology, results, discussion, and conclusion.
CO3	Critically analyze and synthesize relevant literature to construct a comprehensive literature review section in research papers.
CO4	Enhance skills in presenting research findings clearly and concisely through well-structured graphs, tables, and figures.
CO5	Master the use of appropriate citation and referencing styles to avoid plagiarism and acknowledge sources accurately in research writing.

Mapping of COs with POs:

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

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

Course Content

UNIT 1: FOUNDATIONS OF ACADEMIC ENGLISH IN RESEARCH

Academic English - MAP (Message-Audience-Purpose) - Language Proficiency for Writing - Key Language Aspects - Clarity and Precision - Objectivity - Formal Tone - Integrating References - Following Academic Conventions

EFFECTIVE WRITING STYLE FOR RESEARCH PAPERS

Word Order - Sentences and Paragraphs - Link Words for Cohesion - Avoiding Redundancy / Repetition - Breaking up long sentences - Structuring Paragraphs - Paraphrasing Skills – Framing Title and Sub-headings

UNIT 2: ADVANCED READING SKILLS FOR RESEARCHERS

Reading Academic Texts - Critical Reading Strategies - Skimming and Scanning - Primary Research Article vs. Review Article - Reading an Abstract - Analysing Research Articles - Identifying Arguments - Classifying Methodologies - Evaluating Findings - Making Notes

RESEARCH VOCABULARY DEVELOPMENT

Formulaic Expressions - Synonyms and Nuances - Academic Phrase Bank - Discipline-Specific Vocabulary - Formal Expressions and Idioms - Language for Describing Results - Commonly Misused Words - Effective Use of Adjectives and Adverbs

UNIT 3: GRAMMAR REFINEMENT FOR RESEARCH WRITING

Advanced Punctuation Usage - Grammar for Clarity - Complex Sentence Structures - Active-Passive Voice - Subject-Verb Agreement - Proper Use of Modifiers - Avoiding Ambiguous Pronoun References - Verb Tense Consistency - Conditional Sentences

MASTERY IN REVISING, EDITING, AND PROOFREADING

Effective Revisions - Restructuring Paragraph - Editing vs Proofreading Editing for Clarity and Coherence - Rectifying Sentence Structure Issues - Proofreading for Grammatical Precision – Spellings - Tips for Correspondence with Editors

UNIT 4: PRESENTATION LANGUAGE SKILLS

Written vs. Spoken English - Dynamic Vocabulary for Presentations –Expressive Language for Audience Engagement - Q&A Session Preparation Strategies - Language for Clear and Impactful Slides - Adapting Language Style to Different Audiences

UNIT 5: TECHNOLOGY AND LANGUAGE FOR RESEARCH

Digital Literacy and Critical Evaluation of Online Content - Technology and Role of AI in Research Writing – Assistance in Generating Citations and References - Plagiarism and Ethical Considerations – Tools and Awareness – Fair Practices

Books and references

1. Bailey. S. 2015. Academic Writing: A Handbook for International Students. London and New York: Routledge.
2. Craswell, G. 2004. Writing for Academic Success. Sage Publications.
3. Creme, P. & M. Lea. 2008. Writing at University: A guide for students. Open University Press.
4. Oshima, A. & Hogue, A. 2005. Writing Academic English, Addison-Wesley, New York
5. Swales, J. & C. Feak. 2012. Academic Writing for Graduate Students: Essential Skills and Tasks. Michigan University Press.
6. Wallwork, Adrian. 2015. English for Academic Research: Grammar, Usage and Style, Springer, New York
7. ---2011. English for Writing Research Papers, Springer, New York

Semester-III
Control Systems for Electric Vehicle

Course Code:	PEC	Traffic engineering & Intelligent transportation	3-1-0	4 Credits

Teaching Scheme	Examination Scheme
Lecture: 4 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3 hrs duration)

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

CO1	Demonstrate the knowledge and understanding of Electric Vehicle, Hybrid Electric Vehicle Architecture and Configurations.
CO2	Demonstrate the knowledge of the fundamentals of Vehicle propulsion and control.
CO3	Demonstrate the knowledge of how to formulate, analyze and simulate dynamic models of Electric Vehicle components and systems,
CO4	Design and predict the performance of Electrified powertrain.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit-I (10 Hrs)
Introduction to System modelling: Importance of control system in Electrical vehicle, Study of control architecture in Electric vehicle, Systems models and their classifications, principles used in modelling of systems, Fundamental studies of Modelling of vehicle dynamics and control, Longitudinal Vehicle dynamics, Vertical Dynamics model and Lateral vehicle dynamics model, Integrated Vehicle Dynamics.

Unit-II (4 Hrs)
System simulation and validation: System simulation, advantages and disadvantage, steps in simulation study, Simulation of Mechanical and Electrical Systems, Introduction to modelling and

Simulation for Software in loop (SIL) and Hardware in loop (HIL), Study of control architecture.

Unit-III (4 Hrs)
Model based control approach for Electric Vehicle: Introduction to P, PI & PID Controller, and Internal Model Control (IMC) Design, Introduction to Model based control system design for Electric Vehicle.

Unit-VI (13 Hrs)
State Space Representation: Introduction to State Space, State Space Representation, State Space Representation: Companion Form (Controllable Canonical Form), Extended Controllable Canonical Form Observable Canonical Form, Concept of Diagonalization, State transition matrix, Solution of state Equation, Steady State Error for State Space System. Controllability and Observability in State space, Pole Placement by State Feedback and State Observer design.

Unit-V (10 Hrs)

Stability aspects of control systems: Stability concept, Stability definition in the sense of Lyapunov, Stability of continuous time Linear systems, Lyapunov stability theorem, Vehicle stability analysis. Applications: Applications of control techniques in Traction control, Vehicle Control, Electric power steering control.

Suggested Books:

1. R. T. Stefani, B. Shahian, C. J. Savant, Jr., and G. H. Hostetter, Year of Publication/ Reprint 2002

2. Design of Feedback Control Systems, Oxford University Press, Fourth Edition Katsuhiko Ogata, Modern Control Engineering, PHI, Twelfth Edition 2014

3. Ashish Tewari, Modern Control Design: with MATLAB and SIMULINK, Wiley, First Edition 2002

4. L.Umanand, "Power Electronics: Essentials and Applications", Wiley India

5. Rajesh Rajamani, Vehicle Dynamics and Control, Springer, Second Edition 2009 2012

6. Wuwei Chen, Hansong Xiao, Qidong Wang, Linfeng Zhao and Maofei Zhu, Integrated Vehicle Dynamics and Control, Wiley, First Edition 2016

7. Hui Zhang and Dongpu Cao and Haiping Du, Modelling, Dynamics and Control of Electrified Vehicles, WP Publishing, Elsevier 2018

Seminar-II

Course Code:	PCC Lab	Seminar-II	0-0-2	1 Credit

Teaching Scheme	Examination Scheme
Lecture: 2 Hrs/week	Continuous Assessment: 25 Marks End Semester Exam: 25 Marks

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

CO1	Develop research and analytical skills by exploring current topics in EV technology.
CO2	Enhance presentation and communication skills through seminars and discussions.
CO3	Encourage independent learning and critical evaluation of research papers and technical reports.
CO4	Foster collaboration and knowledge sharing among peers and faculty.

Mapping of course outcomes with program outcomes

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

Seminar-I is designed to provide M.Tech students with the opportunity to explore and present on recent advancements, research findings, and emerging trends in the field of Electric Vehicle (EV) Technology. This course emphasizes the development of research skills, critical thinking, and effective communication.

Dissertation-I

Course Code:	PCC	Dissertation-I	10 Credits

Teaching Scheme	Examination Scheme
Lecture: 10 Hrs/week	Continuous Assessment: 50 Marks End Semester Exam: 50 Marks

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

CO1	Clearly define and articulate a research problem in the field of electric vehicle technology.
CO2	Develop a comprehensive research proposal with well-defined objectives, methodology, and expected outcomes.
CO3	Conduct preliminary research, including literature review, data collection, and initial analysis.
CO4	Demonstrate effective technical writing and communication skills.

Mapping of course outcomes with program outcomes

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

Research Proposal: Evaluation of the clarity, relevance, and feasibility of the research proposal.
Progress Reports: Regular assessments of the student's progress, including literature review, preliminary data, and analysis.
Technical Writing: Quality of written documents, including the proposal, progress reports, and preliminary dissertation drafts.
Presentations: Oral presentations to assess the ability to communicate research ideas and progress effectively.
Faculty Advisor Feedback: Continuous feedback and evaluation by the faculty advisor based on meetings, discussions, and submitted work.
Peer Reviews: Constructive feedback from peers to enhance the quality and direction of the research.

Semester-IV
Dissertation-II/Internship

Course Code:	PCC	Dissertation-II/Internship	20 Credits

Teaching Scheme	Examination Scheme
Practicals/Internship: 20 Hrs/week	Continuous Assessment: 100 Marks End Semester Exam: 100 Marks

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

CO1	Clearly define and articulate a research problem in the field of electric vehicle technology.
CO2	Develop a comprehensive research proposal with well-defined objectives, methodology, and expected outcomes.
CO3	Conduct preliminary research, including literature review, data collection, and initial analysis.
CO4	Demonstrate effective technical writing and communication skills.

Mapping of course outcomes with program outcomes

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

Objective:
The final dissertation or industrial internship is the culminating experience of the M.Tech in Electric Vehicle Technology program. Students are required to undertake a significant research project or industrial internship, demonstrating their ability to apply theoretical knowledge to practical problems in the field of electric vehicle technology. The course emphasizes independent research, critical thinking, problem-solving, and effective communication of results.
Assessment:
Dissertation/Internship Proposal: Evaluation of the clarity, relevance, and feasibility of the proposal (10%).
Progress Reports and Meetings: Regular assessments of progress through reports and meetings with advisors (20%).
Final Dissertation/Internship Report: Quality of the written document, including structure, content, analysis, and presentation (40%).

Oral Defense/Presentation: Effectiveness of the oral defense or presentation in communicating research findings or internship outcomes (20%).

Professional Conduct: Assessment of professional behavior, including time management, collaboration, and adherence to ethical standards (10%).