MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE

(Deemed to be University)

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Estd 1998

MASTER OF TECHNOLOGY

Electric Vehicle Technology

Course Structure

&

Detailed Syllabi

For the students admitted to

Master of Technology in Electric Vehicle Technology from the Academic Year 2026 – 27 Batch onwards

M. Tech Regular Two-Year P.G. Degree Course

MADANAPALLE INSTITUTE OF TECHNOLOGY & SCIENCE

(Deemed to be University)

MADANAPALLE

M. Tech Two Year Curriculum Structure

Branch: Electric Vehicle Technology

Total Credits	80 Credits for 2026 Admitted Batch onwards

M. Tech Electric Vehicle Technology

R25 - Curriculum Structure
I Year I Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBEVTTC01	Electric Vehicle System Architecture	3	0	0	3	3
2	PC	25MBEVTTC02	Power Electronic Converters	3	0	0	3	3
3	DE		**Discipline Elective-I** *(Refer ANNEXURE - I)*	3	0	0	3	3
4	DE		**Discipline Elective-II** *(Refer ANNEXURE - I)*	3	0	0	3	3
5	ESC	25MBCOMTC01	Research Methodology and IPR	2	0	0	2	2
6	PC	25MBEVTLC01	EV Simulation and Modeling Laboratory	0	0	4	4	2
7	PC	25MBEVTLC02	Power Electronic Converters Laboratory	0	0	4	4	2
8	SEC	25MBEVTSC01	Scientific Computing for Electric Vehicles	1	0	2	3	2
9	MC	25MBCIVMC01	Disaster Management	2	0	0	2	0
10	EEC		**NSDC - Certification Course – I** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**17**	**0**	**10**	**27**	**20**

I Year II Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBEVTTC03	EV Motor Drives and Control	3	0	0	3	3
2	PC	25MBEVTTC04	Embedded Controllers	3	0	0	3	3
3	DE		**Discipline Elective-III** *(Refer ANNEXURE - I)*	3	0	0	3	3
4	DE		**Discipline Elective-IV** *(Refer ANNEXURE - I)*	3	0	0	3	3
5	OE		**Open Elective-I** *(Refer ANNEXURE – II)*	2	0	0	2	2
6	PC	25MBEVTLC03	EV Motor Drives and Control Laboratory	0	0	4	4	2
7	PC	25MBEVTLC04	Embedded Controllers Laboratory	0	0	4	4	2
8	SEC	25MBEVTSC02	Data Analytics for Electric Vehicles	1	0	2	3	2
9	EEC		**NSDC - Certification Course – II** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**15**	**0**	**10**	**25**	**20**

(L = Lecture, T = Tutorial, P = Practical, C = Credit

R25 – Tentative Curriculum Structure
II Year I Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PC	25MBEVTTC05	EVs in Smart Grid	3	0	0	3	3
2	DE		**Discipline Elective – V** *(Refer ANNEXURE - I)*	3	0	0	3	3
3	OE		**Open Elective- II** *(Refer ANNEXURE - II)*	3	0	0	3	3
4	SEC	25MBCSESC03	Prompt Engineering	1	0	2	3	2
5	PR	25MBEVTIC01	Summer Internship*	0	0	6	6	3
6	PR	25MBEVTPC01	Capstone Project Phase I	0	0	20	20	10
7	EEC		**NSDC - Certification Course – III** *(Refer ANNEXURE – III)*	0	0	2	2	0
Total				**10**	**0**	**28**	**38**	**24**

* 6 Weeks Internship during I Year II Semester Summer Break and to be evaluated in II Year I Semester

II Year II Semester

S. No.	Category	Course Code	Course Title	Hours Per Week				Credits
				L	T	P	Total	
1	PR	25MBEVTPC02	Capstone Project Phase II	0	0	32	32	16
Total				**0**	**0**	**32**	**32**	**16**

(L = Lecture, T = Tutorial, P = Practical, C = Credit

ANNEXURE - I

LIST OF DISCIPLINE ELECTIVE COURSES

Discipline Elective – I		
Sl. No.	**Course Code**	**Course Title**
1.	25MBEVTDC01	Energy Storage Devices and Systems
2.	25MBEVTDC02	Battery Management System
3.	25MBEVTDC03	Thermal Management of EV systems
4.	25MBEVTDC04	Control Systems for Electric Vehicle
Any advanced courses can be appended in future.		

Discipline Elective – II		
Sl. No.	**Course Code**	**Course Title**
1.	25MBEVTDC05	Automotive Engineering
2.	25MBEVTDC06	Special Electrical Machines
3.	25MBEVTDC07	Operational Research
4.	25MBEVTDC08	Vehicle Management and Control
Any advanced courses can be appended in future.		

Discipline Elective – III		
Sl. No.	**Course Code**	**Course Title**
1.	25MBEVTDC09	Life-Cycle Analysis for EV
2.	25MBEVTDC10	Modeling and Analysis of Electrical Machines
3.	25MBEVTDC11	Battery Charging Infrastructure
4.	25MBEVTDC12	EV Standards and Testing
Any advanced courses can be appended in future.		

M. Tech Electric Vehicle Technology

Discipline Elective – IV		
Sl. No.	**Course Code**	**Course Title**
1.	25MBEVTDC13	Automotive Security
2.	25MBEVTDC14	Automotive Electronics
3.	25MBEVTDC15	Computer Vision
4.	25MBEVTDC16	Internet of Things for Electric Vehicle Application
Any advanced courses can be appended in future.		

Discipline Elective – V (To be offered under MOOC's Category from SWAYAM – NPTEL)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBEVTDM01	Intelligent Systems and Control
2.	25MBEVTDM02	Embedded Sensor Networks
3.	25MBEVTDM03	Electromagnetic Compatibility for Automotive Electronics
4.	25MBEVTDM04	Intelligent Controllers for Power Quality Enhancement
Any other new Disciplinary Course which doesn't exist in the Curriculum can be appended in future.		

ANNEXURE - II

LIST OF OPEN ELECTIVE COURSES

Open Elective - I (To be offered under MOOC's Category from SWAYAM – NPTEL)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBCIVOM01	Remote Sensing and GIS
2.	25MBCIVOM02	Sustainable Engineering Concepts and Life Cycle Analysis
3.	25MBMECOM01	Product Engineering and Design Thinking
4.	25MBMBAOM01	Innovation, Business Models and Entrepreneurship
5.	25MBMBAOM02	AI in Human Resource Management
Any other new Inter-Disciplinary Course offered by SWAYAM NPTEL which doesn't exist in the Curriculum can be appended in future.		

Open Elective - II (To be offered under Conventional Mode)		
Sl. No.	**Course Code**	**Course Title**
1.	25MBMECOC01	Automation and Robotics
2.	25MBCSEOC01	Advanced Data Visualization Techniques
3.	25MBCSEOC02	Enterprise Cloud Computing
4.	25MBECEOC01	Community Radio Technology
Any new Interdisciplinary Course can be appended in future.		

I Year I Semester

M. Tech Electric Vehicle Technology

M. Tech I Year I Semester

25MBEVTTC01 ELECTRIC VEHICLE SYSTEM ARCHITECTURE

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces the architecture and integration of major subsystems in Electric Vehicles (EVs), including powertrain, battery systems, power electronics, control systems, and charging infrastructure. It covers EV communication networks, battery management systems, energy management strategies, and smart grid integration. The course enables students to understand the design, operation, and performance analysis of modern electric vehicle systems.

Course Objectives:

This course enables students to

1. To introduce the overall architecture of Electric Vehicle systems.
2. To understand EV subsystems and their integration.
3. To analyze EV powertrain architecture and energy flow.
4. To study communication, control, and battery management systems in EVs.
5. To understand charging infrastructure and vehicle-to-grid integration.

UNIT I INTRODUCTION TO ELECTRIC VEHICLE SYSTEM ARCHITECTURE — 9 hours

Introduction to Electric Vehicles: Evolution of EVs, Types of EVs (BEV, HEV, PHEV, FCEV), comparison with IC engine vehicles, present trends and future scope. EV System Architecture: Overall EV architecture, functional block diagram, subsystem interaction, vehicle-level energy flow, distributed and centralized architectures. Major EV Subsystems: Energy source, traction motor, power electronic converters, controller, transmission system, auxiliary systems, thermal management system.

UNIT II EV POWERTRAIN ARCHITECTURE — 9 hours

EV Powertrain Configuration: Front-wheel drive, rear-wheel drive, all-wheel drive, single motor and multi-motor architecture, in-wheel motor architecture. Traction System Components: Electric traction motor selection, transmission systems, reduction gear mechanisms, differential systems, regenerative braking architecture. Power Electronics in EVs: DC-DC converters, inverters, onboard chargers, converter topologies, wide band-gap semiconductor devices for EV applications. Energy Flow Control: Vehicle control unit (VCU), torque control strategy, energy optimization, drive cycle considerations.

UNIT III BATTERY SYSTEM ARCHITECTURE AND ENERGY MANAGEMENT — 9 hours

Battery Pack Architecture: Cell, module and pack configuration, battery chemistries, battery sizing, series and parallel connections. Battery Management System (BMS): SOC estimation, SOH estimation, cell balancing, thermal monitoring, protection mechanisms, fault diagnostics. Thermal Management Systems: Air cooling, liquid cooling, phase change materials, battery thermal runaway protection. Energy Management Strategies: Power distribution, regenerative braking energy recovery, hybrid energy storage systems, super-capacitor integration.

UNIT IV COMMUNICATION AND CONTROL ARCHITECTURE — 9 hours

Vehicle Communication Networks: CAN, LIN, FlexRay, Automotive Ethernet, communication protocols and standards. Electronic Control Units (ECUs): Distributed control architecture, embedded controllers, sensor integration, actuator systems. Functional Safety: ISO 26262 overview, fault-tolerant architecture, diagnostics and redundancy systems.

UNIT V CHARGING INFRASTRUCTURE AND SMART GRID INTEGRATION **9 hours**

EV Charging Architecture: AC charging, DC fast charging, onboard and off board charging systems, charging standards (CCS, CHAdeMO, GB/T, Bharat DC001). Charging Infrastructure: Home charging stations, public charging stations, battery swapping stations, wireless charging systems. Grid Integration: Smart charging, Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H), demand response management. Future Trends in EV Architecture: Connected EVs, cloud-based vehicle diagnostics, AI-based energy management, digital twin technology in EV systems.

Course Outcomes:

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

CO1: Explain the overall architecture and subsystems of electric vehicles.

CO2: Analyze EV powertrain configurations and energy flow mechanisms.

CO3: Evaluate battery system architecture and battery management strategies.

CO4: Interpret communication protocols and control architectures used in EVs.

CO5: Analyze EV charging infrastructure and smart grid integration techniques.

Text Book(s)

1. Mehrdad Ehsani, Yimin Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design* CRC Press, Second Edition.
2. James Larminie and John Lowry, *Electric Vehicle Technology Explained,* Wiley Publications, Second Edition.
3. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals, CRC* Press.
4. Ali Emadi (Ed.), *Advanced Electric Drive Vehicles,* CRC Press.
5. Sheldon S. Williamson, *Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles,* Springer.

Reference Books

1. Robert Bosch GmbH, Bosch *Automotive Electrics and Automotive Electronics, Wiley* Publications.
2. Tom Denton, *Automobile Electrical and Electronic Systems,* Routledge / Elsevier.
3. Sandeep Dhameja, *Electric Vehicle Battery Systems,* Newnes Publication.
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid *Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley* Publications.
5. M. Baranwal and A. Choudhury, Electric *Vehicle Systems and Architecture, McGraw* Hill Education.

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech Electric Vehicle Technology

M. Tech I Year I Semester

25MBEVTTC02 POWER ELECTRONIC CONVERTERS

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces power electronic converters concepts and their applications in electric vehicle systems including connected vehicles, battery monitoring, smart charging, etc.

Course Objectives:

1. Understand the essentials of power conversion.
2. Design practical non isolated converters.
3. Design practical offline converters.
4. Design practical isolated converters.
5. Bidirectional converter topologies for Electric Vehicles.

UNIT I POWER SEMICONDUCTOR DEVICES 9 hours

Ideal and Typical Power Switching Waveforms, Ideal and Typical Power Device Characteristics, Unipolar Power Devices, bipolar Power Devices, MOS-Bipolar Power Devices. Introduction to Power Conversion - Converting power with resistors, Converting power with switches, the duty cycle factory, buck converter, boost converter, buck-boost Converter, Input filtering, RLC filter.

UNIT II NON-ISOLATED CONVERTERS 9 hours

Buck converter, Boost converter, Buck-Boost converter, analysis design and simulation.

UNIT III STAND-ALONE CONVERTERS 9 hours

Rectifier Bridge: Capacitor selection, Diode Conduction Time, RMS Current in the Capacitor, Current in the Diodes, Input Power Factor, Hold-Up Time, In-Rush Current Power Factor Correction: Definition of Power Factor, Non-sinusoidal Signals, A Link to the Distortion, Why Power Factor Correction? Harmonic Limits, A Need for Storage, Passive PFC, Improving the Harmonic Content, The Valley-Fill Passive Corrector, Active Power Factor Correction, Constant on-time borderline mode (BCM), fixed- frequency continuous mode (CCM), Analytical control law.

UNIT IV ISOLATED CONVERTERS 9 hours

Simulations and practical designs of flyback converters, an isolated buck-boost, flyback waveforms without parasitic elements, flyback waveforms with parasitic elements, clamping the drain excursion, designing the clamping network, two-switch flyback, simulations and practical designs of forward converters, an isolated buck converter, need for a complete core reset, a two-switch configuration, two switch forward and half-bridge driver.

UNIT V BIDIRECTIONAL CONVERTER TOPOLOGIES FOR PLUG-IN ELECTRIC VEHICLES 9 hours

Introduction, Literature Survey, Bidirectional Converters, Bidirectional AC/DC Converters for Plug-In EV with Reduced Conduction Losses, Topology Explanation, Plug-In Charging Mode, Propulsion Mode, Boost Operation, Buck Operation, Regenerative Braking Operation, Boost Operation, Buck Operation Bidirectional Battery Charger for an Electric Vehicle Bidirectional Power Flow Converters.

M. Tech Electric Vehicle Technology

Course Outcomes:

At the end of the course student will be able to:
CO1: Analyze the operation of different power converters.
CO2: Design of non-isolated converters used in electric vehicles.
CO3: Design front end for practical offline converters.
CO4: Analyze the operation of practical isolated converters.
CO5: Analyze the Bidirectional converter topologies used in Electric Vehicles.

Text Book(s)

1. B. Jayant Baliga, "*Power Semiconductor Devices*", 1st Edition, International Thompson Computer Press, 1995.
2. Christophe Basso, "*Switch Mode Power Supplies: SPICE Simulations and Practical Designs*", McGraw Hill,2008.

Reference Books

1. L. Ashok Kumar, S. Albert Alexander, "*Power Converters for Electric Vehicles*", CRC Press, Taylor & Francis Group, 2021.
2. Dharavath Kishan, Ramani Kannan, B. Dastagiri Reddy, "*Power Electronics for Electric Vehicles and Energy Storage: Emerging Technologies and Developments*", CRC Press, 2023.
3. Ned Mohan, Tore M. Undeland, and William P. Robbins, "*Power Electronics: Converters, Applications, and Design*", John Wiley & Sons , 2022, 3rd Edition.

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech Electric Vehicle Technology

M. Tech I Year I Semester

25MBCOMTC01 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	0	0	2

Pre-requisite Nil

Course Description:

This course aims to provide students with a comprehensive understanding of research methodology and the principles and practices of intellectual property rights (IPR). The course will equip students with the skills needed to design, conduct, and evaluate research effectively while also understanding the legal and ethical considerations surrounding intellectual property.

Course Objectives:

To impart knowledge on

1. Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
2. Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9 hours

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9 hours

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9 hours

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9 hours

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR, IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9 hours

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

M. Tech Electric Vehicle Technology

Course Outcomes:

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

Text Book(s)

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, "Research methodology for natural sciences", IISc Press, Kolkata, 2022.
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.

Reference Books

1. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
2. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech Electric Vehicle Technology

M. Tech I Year I Semester

25MBEVTLC01 EV SIMULATION AND MODELING LABORATORY

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

The EV Simulation and Modeling Laboratory is designed to provide hands-on understanding and practical exposure to electric vehicle system modelling, simulation, and performance analysis using modern software tools such as MATLAB/Simulink. This course enables students to bridge the gap between theoretical EV concepts and real-world electric mobility applications through simulation-based experimentation. Experiments focus on modelling EV subsystems such as batteries, electric drives, converters, charging systems, and vehicle dynamics. Students also study energy management strategies, regenerative braking, and drive-cycle analysis for electric vehicles.

Course Objectives:

By the end of this course, the student will be able to:

1. To understand and model electric vehicle subsystems including batteries, motors, converters, and vehicle dynamics using simulation tools.
2. To analyze the performance characteristics of electric propulsion systems under different operating conditions.
3. To study regenerative braking, battery management, and energy optimization techniques in electric vehicles.
4. To evaluate electric vehicle performance using standard drive cycles and simulation-based testing methods.
5. To develop integrated EV system models and analyze energy consumption, efficiency, and control strategies.

List of Experiments:

(Any 10 of the following experiments are to be conducted)

1. Modelling and simulation of electric vehicle drivetrain using simulation tools.
2. Simulation of lithium-ion battery characteristics and State of Charge (SOC) estimation.
3. Performance analysis of BLDC motor drive for EV applications.
4. Simulation and analysis of PMSM drive system for electric vehicles.
5. Modelling and analysis of DC-DC converters used in EV systems.
6. Simulation of regenerative braking systems in electric vehicles.
7. Drive cycle analysis using standard EV drive cycles such as UDDS and FTP cycles.
8. Simulation of battery thermal management systems.
9. Energy consumption and efficiency analysis of electric vehicles under varying load conditions.
10. Simulation of electric vehicle charging systems and charging characteristics.
11. Vehicle dynamics modelling under different road and driving conditions.
12. Comparative analysis of different energy management strategies in EV systems.
13. Integrated modelling and simulation of complete electric vehicle systems.

Course Outcomes:

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

CO1: Develop and simulate electric vehicle subsystem models using modern simulation tools.

CO2: Analyze the performance characteristics of batteries, motors, and converters used in EV systems.

CO3: Evaluate regenerative braking and energy management techniques in electric vehicles.

CO4: Analyze vehicle dynamics and drive-cycle performance of electric vehicles.

CO5: Design and validate integrated EV simulation models for performance and efficiency analysis.

Text Book(s)

1. Mehrdad Ehsani, Yimin Gao and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*, CRC Press, 2018.
2. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2012.
3. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2011.
4. MATLAB/Simulink Documentation for Electric Vehicle Modelling.

Reference Books

1. Sheldon S. Williamson, *Energy Management Strategies for Electric and Hybrid Vehicles*, Springer, 2013.

Mode of Evaluation: Continuous Internal Evaluation and End Semester Examination

M. Tech Electric Vehicle Technology

M. Tech I Year I Semester

25MBEVTLC02 POWER ELECTRONIC CONVERTERS LABORATORY

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces power electronic converters concepts and their applications in electric vehicle systems including connected vehicles with its other parameters, etc.

Course Objectives:

1. Understand the design and operation of buck converter.
2. Understand and design synchronous and buck-boost converter powered by car battery.
3. Understand the design and operation of rectifier with PFC.
4. Understand the design and operation of flyback and forward converter.
5. Understand the operation of non-isolated bidirectional onboard charger and inverter.

List of Experiments:

(Any 10 of the following experiments are to be conducted)

1. Design and simulate a voltage mode buck converter and study the effect of ESR of filter capacitor used on the performance of the converter.
2. Design and simulate a current mode buck converter for car battery.
3. Design and simulate synchronous buck converter and compare its efficiency with buck converter.
4. Design and simulate a buck-boost converter operated from a car battery.
5. Designs a 100 W rectifier operated on universal mains and demonstrate the starting inrush current.
6. Design and simulate the passive PFC for a rectifier circuit.
7. Design and simulate flyback converter without parasitic elements.
8. Design and simulate a two-switch forward converter using two MOSFETs and a couple of diodes to recycle the magnetizing energy.
9. Design and simulate non-isolated bidirectional onboard charger.
10. Design and simulate DC- AC converter using IGBT.

Course Outcomes:

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

CO1: Analyze the effect ESR of filter capacitor on the performance of the buck converter.

CO2: Compare the performance of synchronous buck converter with buck converter.

CO3: Design rectifier operated on universal mains with the feature of PFC.

CO4: Design flyback and forward converter.

CO5: Analyze non-isolated bidirectional onboard charger and inverter. Analyze the effect ESR of filter capacitor on the performance of the buck converter.

Text Book(s)

1. Christophe Basso, “Switch Mode Power Supplies: SPICE Simulations and Practical Designs”, McGraw-Hill, 2008.

Mode of Evaluation: Continuous Internal Evaluation and End Semester Examination.

M. Tech I Year I Semester
Skill Enhancement Course – I

25MBEVTSC01 SCIENTIFIC COMPUTING FOR ELECTRIC VEHICLES

L	T	P	C
1	0	2	2

Pre-requisite: Nil

Course Description:

This course provides a comprehensive foundation in numerical methods and computational computing tailored specifically for analysing, modeling, and optimizing Electric Vehicle (EV) systems. Students will bridge the gap between abstract mathematical theories and real-world automotive engineering challenges by exploring error analysis, numerical linear algebra, ordinary and partial differential equations, and scientific optimization techniques. The curriculum emphasizes multi-physics simulations, including electrochemical battery modeling (thermal runway and degradation tracking), power electronics state-space transient dynamics, and permanent magnet synchronous motor (PMSM) electromagnetic field analysis. Through hands-on programming implementations using MATLAB/Simulink and Python (NumPy/SciPy), students will develop the advanced engineering skills required to build high-fidelity virtual prototypes, design predictive Battery Management System (BMS) algorithms, and optimize powertrain efficiency.

Course Objectives:

The main objectives of the course are to

1. Equip students with a deep understanding of error propagation, truncation limits, and iterative root-finding techniques for high-accuracy sensor data processing in EVs.
2. Enable students to design and implement efficient linear solvers for massive network equations representing battery balancing circuits and power grid demands.
3. Teach students how to formulate and solve systems of ordinary differential equations (ODEs) to simulate real-time vehicle acceleration, regenerative braking, and cell thermal profiles.
4. Introduce discretization methods (FDM/FEM) to analyze multi-dimensional partial differential equations (PDEs) governing battery lithium-ion diffusion and motor magnetic flux.
5. Train students to apply constrained optimization and curve-fitting algorithms for optimal energy management strategies and accurate state estimation (SoC/SoH).

UNIT I INTRODUCTION AND ERROR ANALYSIS 6 hours

Computational Modeling: Role of scientific computing in EV system design. Number Systems & Errors: Floating-point arithmetic, round-off, truncation errors, absolute and relative errors, propagation of errors in EV measurements. Root Finding: Bisection, Newton-Raphson, and Secant methods applied to non-linear electrical/thermal equations.

Experiments:

1. Truncation Error in Sensor Taylor Series
2. Round-Off Error Accumulation in Coulomb Counting
3. Newton-Raphson for Diode Shockley Equation
4. Secant Method for Cell Terminal Voltage
5. Condition Number of Motor Efficiency Modeling

UNIT II NUMERICAL LINEAR ALGEBRA & MATRIX COMPUTATIONS 6 hours

System of Linear Equations: Direct methods (Gaussian elimination, LU decomposition).Iterative Solvers: Jacobi, Gauss-Seidel, and Conjugate Gradient methods for sparse matrices arising from massive battery pack mesh networks. Eigenvalue Problems: Power method and QR algorithm for system stability and modal analysis of EV powertrains.

Experiments:

1. LU Decomposition for Battery Interconnect Networks
2. Gauss-Seidel Iteration for Thermal Mesh Nodes
3. Power Method for Drivetrain Vibrations
4. Sparse Matrix Storage for Battery Management Systems (BMS)
5. Conditioned Charging Network Analysis

UNIT III ORDINARY DIFFERENTIAL EQUATIONS (ODES) FOR EV DYNAMICS 6 hours

Initial & Boundary Value Problems: Euler's method, Runge-Kutta methods. Dynamic System Simulation: Solving transient state equations for vehicle longitudinal dynamics, acceleration, and braking performance profiles. Battery Thermal Models: Numerical integration of lumped-capacitance thermal lumped models for lithium-ion cell heating and cooling cycles.

Experiments:

1. Euler's Method for Vehicle Acceleration Profiling
2. Fourth-Order Runge-Kutta for Battery Lumped Thermal Model
3. Stiffness Analysis of DC-DC Converter State-Space Equations
4. Adaptive Step Size for Regenerative Braking Simulation
5. Boundary Value Problem (BVP) for Cooling Plate Liquid Channels.

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS (PDES) & FIELD SIMULATIONS 6 hours

Discretization Techniques: Finite Difference Method (FDM) and introduction to Finite Element Method (FEM). Electrochemistry & Thermal Diffusion: Numerical solution of 1D/2D diffusion equations for lithium-ion concentration gradients inside battery electrodes. Magnetic Field Simulation: Solving Poisson's and Laplace's equations for flux distribution in permanent magnet synchronous motors (PMSM).

Experiments:

1. Explicit Finite Difference Method for 1D Thermal Diffusion
2. Implicit Crank-Nicolson Scheme for Solid-Phase Lithium Diffusion
3. Laplace Equation for PMSM Rotor Magnetic Vector Potential
4. Weak Formulation for Finite Element Analysis (FEA) of Motor Shafts
5. Finite Volume Method (FVM) for Battery Coolant Fluid Flo

UNIT V OPTIMIZATION AND SIMULATION TOOLS 6 hours

Numerical Optimization: Unconstrained and constrained optimization (Linear/Non-linear programming) for EV energy management and sizing. Parameter Estimation: Curve fitting, least-squares regression, and interpolation for State-of-Charge (SoC) and State-of-Health (SoH) estimation algorithms. Software Implementation: Overview of MATLAB/Simulink, Python-based numerical packages (NumPy/SciPy), and solving case studies for power converter efficiency optimization.

Experiments:

1. Linear Programming for EV Fleet Energy Sizing
2. Least-Squares Curve Fitting for SoC vs Open-Circuit Voltage
3. Lagrange Interpolation for Motor Torque De-rating Curves
4. Unconstrained Optimization for Powertrain Efficiency
5. Software Integration Case Study: Battery Parameter Estimation

Course Outcomes:

Upon successful completion of the course, students will be able to

CO1: Quantify and mitigate numerical errors in real-time EV embedded controllers, ensuring robust algorithm performance under sensor noise.

CO2: Construct and execute high-speed matrix solvers to accurately evaluate complex balancing systems and multi-node inverter heat sink profiles.

CO3: Develop high-fidelity dynamic models of EV powertrains and cell packs using advanced ordinary differential equation (ODE) integration schemes.

CO4: Program numerical solutions for partial differential equations (PDEs) to visualize internal cell chemical diffusion and motor electromagnetic fields.

CO5: Implement industry-standard software tools (Python/MATLAB) to maximize vehicle efficiency and synthesize optimal parameter estimation code for BMS applications.

Text Book(s)

1. STEVEN, C. CHAPRA. Applied Numerical Methods with Matlab: For Engineers and Scientists. Tata McGraw Hill Education Private Limited, 2007.
2. Xu, Sheng. An Introduction to Scientific Computing with Matlab® and Python Tutorials. CRC Press, 2022.
3. Führer, C., Fuhrer, C., Solem, J. E., & Verdier, O. (2021). Scientific Computing with Python: High-performance scientific computing with NumPy, SciPy, and pandas. Packt Publishing Ltd.

Reference Books

1. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
2. Emadi, Ali, ed. Advanced electric drive vehicles. CRC Press, 2014.
3. Husain, Iqbal. Electric and hybrid vehicles: design fundamentals. CRC press, 2003.

Mode of Evaluation: Continuous Internal Evaluation, Assignments, Mid Term Tests and End Semester Examination.

M. Tech Electric Vehicle Technology
Mandatory Course

26BFCIVVC01 DISASTER MANAGEMENT

L	T	P	C
2	0	0	2

Pre-requisite: Nil

Course Description:

This course provides a comprehensive understanding of natural and human-induced disasters, their causes, characteristics, and consequences. It examines the social, economic, environmental, and life-safety impacts of disasters with emphasis on disaster-prone regions in India. The course introduces disaster preparedness and management through monitoring, risk evaluation, remote sensing, meteorological information, and community participation. It develops knowledge of disaster risk assessment, disaster risk reduction, early warning, and national and global cooperation. The course also focuses on structural and non-structural mitigation strategies and emerging approaches for reducing disaster vulnerability and impacts.

Course Objectives:

Upon the completion of subject student will be able to-

1. Develop fundamental knowledge of different natural and man-made disasters, their characteristics, causes, and associated hazards.
2. Examine the economic, environmental, ecological, and human consequences of disasters and identify disaster-prone regions in India.
3. Develop an understanding of disaster preparedness and management using monitoring systems, remote sensing, meteorological information, and community-based approaches.
4. Introduce the concepts, elements, and techniques of disaster risk assessment, risk reduction, early warning, and national and global cooperation.
5. Develop knowledge of structural and non-structural disaster mitigation strategies, emerging mitigation practices, and disaster mitigation programmes in India.

UNIT I DISASTER CLASSIFICATION **6 hours**

Disaster: definition, factors and significance; difference between hazard and Disaster; natural disaster: earthquakes, volcanisms, cyclones, tsunamis, floods, droughts and famines, landslides and avalanches; man-made disasters: nuclear reactor meltdown, industrial accidents, oil slicks and spills, outbreaks of disease and epidemics, war and conflicts

UNIT II REPERCUSSIONS OF DISASTERS **6 hours**

Economic damage, loss of human and animal life, destruction of ecosystem. Disaster Prone Areas in India: Study of seismic zones; areas prone to floods and droughts, landslides and Avalanches; areas prone to cyclonic and coastal hazards with special reference to tsunami.

UNIT III DISASTER PREPAREDNESS AND MANAGEMENT **6 hours**

Preparedness: monitoring of phenomena triggering a disaster or hazard; Evaluation of risk: application of remote sensing, data from meteorological and Other agencies, media reports: governmental and community preparedness.

UNIT IV RISK ASSESSMENT **6 hours**

Disaster risk: concept and elements, disaster risk reduction, global and national disaster risk situation. Techniques of risk assessment, global co-operation in risk assessment and warning.

UNIT V DISASTER MITIGATION **6 hours**

Meaning, concept and strategies of disaster mitigation, emerging trends in Mitigation. Structural mitigation and non-structural mitigation, programs of Disaster mitigation in India.

Course outcomes:

After the completion of the subject following outcomes can be achieved-

CO1: Classify natural and man-made disasters and explain their causes, characteristics, and associated hazards.

CO2: Assess the major economic, environmental, ecological, and human impacts of disasters and identify disaster-prone regions in India.

CO3: Explain disaster preparedness and management practices using hazard monitoring, remote sensing, meteorological data, and community preparedness mechanisms.

CO4: Apply appropriate techniques for disaster risk assessment and explain disaster risk reduction, early warning systems, and national and global cooperation mechanisms.

CO5: Evaluate and recommend suitable structural and non-structural mitigation measures for reducing disaster risk and impacts.

Reference Books:

1. Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation
2. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
3. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi.
4. Goel S. L., Disaster Administration And Management Text and Case Studies" ,Deep&Deep Publication Pvt. Ltd., New Delhi

Mode of Evaluation: Assignments, Mid Term Tests

I Year II Semester

M. Tech Electric Vehicle Technology

M. Tech I Year II Semester

25MBEVTTC03 EV MOTOR DRIVES AND CONTROL

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course familiarizes students with the concept of electric vehicles, power train for electric vehicles and electric drives used in electric vehicles and their control.

Course Objectives:

1. Understand the essentials of electric vehicles.
2. Design a practical electric motor.
3. Design practical on-board chargers.
4. Understand and design the control of Induction Motor drives.
5. High Speed techniques for Electric Vehicles.

UNIT I COMPONENTS OF POWER TRAIN 9 hours

History and benefits of electric vehicles; fundamentals of EVs; tractive effort; vehicular dynamics; drive cycle and vehicle control unit, Components of conventional vehicle and propulsion load; power train of HEV and EV; efficiency considerations for conventional vehicle, HEV and EV; multi-motor in-wheel EVs; impact and benefits of EV on utility grid.

UNIT II ELECTRIC MOTOR DRIVES FOR EV APPLICATIONS 9 hours

Concept of EV motors, Classification of EV motors, and Comparison of Electric motors for EV applications, Recent EV motors, BLDC and SRM, axial flux motor. Introduction to power electronics converters, DC-DC converter, speed control of dc motor, BLDC motor driving schemes.

UNIT III ON-BOARD CHARGERS 9 hours

Review of semiconductor devices; turn-on and turn-off characteristics, loss computation in semiconductor devices; basics of non-isolated/ isolated DC-DC and grid connected converters; classification of EV chargers; modelling and control of bi-directional DC-DC converters; discussions on V2X applications.

UNIT IV INDUCTION MOTOR DRIVES 9 hours

Basics of induction motor; open-loop v/f control; basics of DC-AC power converters; basic pulse width modulation techniques; vector control of IM drives; advanced control techniques.

UNIT V HIGH-POWER AND HIGH-SPEED EVS 9 hours

Applications of High-power induction motor drives; power converter design; special PWM techniques for high-power applications; field-oriented control of high-power IM drives; applications of high speed PMSM drives; power converter design and PWM techniques; field-oriented control of high-speed PMSM drives.

Course Outcomes:

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

CO1: Analyze the operation of different power train for electric vehicles.

CO2: Design of non-isolated converters used in electric vehicles.

CO3: Design front end for practical onboard chargers.

CO4: Analyze the operation of Induction Motor drives.

CO5: Analyze the use of high-speed topologies used in Electric Vehicles.

Text Book(s)

1. Kwang Hee Nam, “AC Motor Control and Electrical Vehicle Applications”, Taylor & Francis / CRC Press, 2020 (2nd Edition).
2. Ned Mohan and Siddharth Raju, “Analysis and Control of Electric Drives: Simulations and Laboratory Implementation”, Wiley-Blackwell Publisher, 2020.
3. Yiqing Yuan, “Electric Vehicles: Theory and Design”, SAE International Publisher, 2024.

Reference Books

1. R. Krishnan, “Electric Motor Drives: Modelling, Analysis and Control”, Pearson Education Publisher, 2001 (Classic edition) / 2025 (Revised/Reprint).

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech I Year II Semester

25MBEVTTC04 EMBEDDED CONTROLLERS

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course focuses on embedded controllers used in electric vehicle and automotive applications, covering microcontrollers, digital signal controllers, interrupts, timers, ADC, PWM, I/O modules, embedded interfacing, controller programming, and controller-based drive applications.

Course Objectives:

1. To understand the architecture and operation of embedded processors, microcontrollers, and digital signal controllers used in EV systems.
2. To study controller peripherals such as interrupt controllers, DMA, timers, ADC, PWM, serial interfaces, and digital I/O.
3. To develop embedded controller programming skills for measurement, communication, and actuation tasks
4. To apply embedded controllers in motor drives, battery systems, and automotive interfaces.
5. To analyze controller selection and implementation issues in real-time automotive applications.

UNIT I EMBEDDED CONTROLLER FUNDAMENTALS 9 hours

Introduction to embedded systems; microprocessor and microcontroller concepts; architecture of embedded processors and controllers; role of embedded controllers in automotive and EV applications.

UNIT II DIGITAL SIGNAL CONTROLLERS AND PERIPHERALS 9 hours

Overview of digital signal controller families; interrupt controller and DMA controller; timer modules; ADC modules; PWM generation; input/output modules and peripheral organization for control applications.

UNIT III EMBEDDED INTERFACING AND PROGRAMMING 9 hours

Embedded controller programmable interface; A/D and D/A interfacing; keypad, LCD, UART and serial communication interfaces; digital voltmeter; PWM-based motor speed controller implementation; programming methods for controller-based applications.

UNIT IV CONTROLLERS IN EV DRIVE AND POWER ELECTRONIC SYSTEMS 9 hours

Role of controllers in EV motors and controllers; motor control strategies for BLDC and PMSM drives; power controllers; converter control; real-time implementation issues in traction and auxiliary systems.

UNIT V AUTOMOTIVE EMBEDDED CONTROL APPLICATIONS 9 hours

Embedded control applications and case studies; controller-based sensing and diagnostics; automotive communication interface requirements; hardware-in-the-loop and simulation-supported controller development for automotive systems.

Course Outcomes:

At the end of the course, the students will be able to:
CO1: Explain the structure and operation of embedded controllers used in EV systems.
CO2: Configure and analyze controller peripherals including interrupts, timers, ADC, and PWM.
CO3: Develop basic embedded programs for sensing, interfacing, and actuation.
CO4: Apply controllers in motor-drive and power-electronic automotive subsystems.
CO5: Design and evaluate embedded control solutions for automotive applications.

Text Book(s)

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, *The 8051 Microcontroller and Embedded Systems*.
2. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*.

Reference Books

1. Microchip dsPIC33 family digital signal controller documentation and application notes (as indicated by digital controller topics in the syllabus source).
2. Frank Vahid and Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*.
3. Ali Emadi, *Handbook of Automotive Power Electronics and Motor Drives*.

Mode of Evaluation: Assignments, Mid Term Tests, End Semester Examination.

M. Tech I Year II Semester

25MBEVTLC03 EV MOTOR DRIVES AND CONTROL LABORATORY

L	T	P	C
0	0	4	2

Pre-requisite Nil

Course Description:

The EV Motor Drives and Control Laboratory is designed to provide practical exposure to electric vehicle propulsion systems and motor control techniques through experimental investigation and simulation-based analysis. This course enables students to understand the operation, control, and performance characteristics of electric drives used in electric vehicles. Experiments focus on DC motor drives, BLDC motor drives, PMSM drives, induction motor drives, regenerative braking systems, and controller implementation using modern software and hardware platforms. The laboratory also emphasizes speed control, torque control, PWM techniques, and energy-efficient operation of EV traction systems.

Course Objectives:

By the end of this course, the student will be able to:

1. To understand the operating principles and control techniques of electric motor drives used in electric vehicles.
2. To analyze the performance characteristics of DC, BLDC, PMSM, and induction motor drives under various operating conditions.
3. To study PWM techniques, speed control methods, and torque control strategies for EV propulsion systems.
4. To evaluate regenerative braking operation and energy-efficient control methods in electric vehicle applications.
5. To design and validate EV drive control systems using simulation and hardware-based experimentation.

List of Experiments:

(Any 10 of the following experiments are to be conducted)

1. Speed control of DC motor using chopper-fed drive.
2. PWM control and performance analysis of BLDC motor drive.
3. Simulation of PMSM drive system for EV applications.
4. Vector control of induction motor drive using Simulation tools.
5. Study of regenerative braking operation in electric motor drives.
6. Torque-speed characteristic analysis of EV traction motors.
7. Battery-fed motor drive performance evaluation.
8. Implementation of PI controller for DC motor speed control.
9. Implementation and analysis of PID controller for EV motor drive systems.
10. Comparative analysis of BLDC and PMSM drives for EV applications.
11. Simulation of inverter-fed AC motor drive systems.
12. Fault analysis and protection techniques in EV motor drives.
13. Integrated modelling and control of EV propulsion systems.

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Course Outcomes:

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

CO1: Analyze the operating characteristics of electric motor drives used in electric vehicles.
CO2: Apply speed and torque control techniques for EV propulsion systems.
CO3: Implement PWM-based motor control methods using simulation and hardware tools.
CO4: Evaluate regenerative braking and energy-efficient drive operation in EV systems.
CO5: Design and validate EV motor drive control systems for improved performance and efficiency.

Text Book(s)

1. R. Krishnan, *Electric Motor Drives: Modeling, Analysis and Control*, Prentice Hall, 2001.
2. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2011.
3. Bimal K. Bose, *Modern Power Electronics and AC Drives*, Pearson Education, 2002.

Reference Books

1. Ned Mohan, *Power Electronics: Converters, Applications and Design*, Wiley India, 2014.
2. MATLAB/Simulink Documentation for Electric Drive Systems.

Mode of Evaluation: Continuous Internal Evaluation and End Semester Examination.

M. Tech Electric Vehicle Technology

M. Tech I Year II Semester

25MBEVTLC04 EMBEDDED CONTROLLERS LABORATORY

L	T	P	C
0	**0**	**4**	**2**

Pre-requisite Nil

Course Description:

This laboratory course provides practical exposure to embedded controllers used in automotive and electric vehicle applications. The course focuses on microcontroller programming, sensor interfacing, communication protocols, real-time embedded systems, and automotive ECU applications using modern development tools.

Course Objectives:

By the end of this course, the student will be able to:

1. To understand embedded controller hardware and software platforms.
2. To develop embedded programs for automotive applications.
3. To interface sensors and actuators with embedded systems.
4. To implement communication protocols used in automotive systems.
5. To design and test real-time embedded controller applications.

List of Experiments:

1. Study of embedded development tools and IDE.
2. GPIO programming and LED interfacing.
3. Interfacing temperature and ultrasonic sensors.
4. Motor control using embedded controllers.
5. Implementation of UART communication.
6. Implementation of SPI and I2C protocols.
7. CAN communication for automotive applications.
8. Real-time task scheduling using RTOS.
9. Battery monitoring system implementation.
10. IoT-based automotive monitoring application.

Course Outcomes:

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

1. Develop embedded programs using microcontroller platforms.
2. Interface sensors and actuators for automotive applications.
3. Implement automotive communication protocols.
4. Analyze and test real-time embedded controller systems.
5. Design advanced embedded applications for automotive and EV systems.

Reference Books

1. Embedded Controllers Using C and Arduino: Laboratory Manual by James M. Fiore

Mode of Evaluation: Continuous Internal Evaluation and End Semester Examination.

M. Tech I Year II Semester
Skill Enhancement Course - II

25MBEVTSC02 DATA ANALYTICS FOR ELECTRIC VEHICLES

L	T	P	C
1	0	2	2

Pre-requisite: Nil

Course Description:
Modern Electric Vehicles (EVs) operate as mobile data centers, continuously generating complex, high-frequency data streams from Battery Management Systems (BMS), motor controllers, and telematics units. This course provides M. Tech. students with the specialized data science competencies required to process, analyze, and extract actionable insights from real-world EV data.

Course Objectives:
The main objectives of the course are to

1. Equip students with the ability to write robust Python scripts utilizing NumPy and Pandas to efficiently parse, clean, and manipulate high-frequency data streams derived from EV telematics and CAN bus logs.
2. Train students to analyze vehicle data quality by applying statistical techniques and time-series alignment to isolate sensor noise, voltage spikes, and abnormal thermal readings.
3. Enable students to design and interpret advanced graphical representations of EV metrics, such as Voltage vs. State of Charge (SoC) curves, drive cycles, and regenerative braking profiles.
4. Guide students in constructing and tuning regression models to accurately forecast EV energy consumption, real-time driving range, and battery State of Health (SoH).
5. Empower students to deploy supervised and unsupervised machine learning algorithms to automate the detection of cell imbalances, classify vehicle faults, and cluster charging behaviours.

UNIT I PYTHON ESSENTIALS & EV DATA STRUCTURES 9 hours

Core Python Programming: Variables, control structures, functions, object-oriented concepts, and exception handling for streaming data. Numerical Computing with NumPy: Multi-dimensional arrays, vectorisation, and mathematical operations on sensor timelines. Data Manipulation with Pandas: Data Frames, Series, indexing, slicing, and merging disparate vehicle logs. EV Data Formats: Parsing JSON, CSV, and CAN bus (Controller Area Network) log structures. Hands-on Lab

Experiments:

1. Explain how a Controller Area Network (CAN) bus log differs from standard tabular data (like a CSV). How does Python's `json` module handle nested telematics data?
2. Compare the memory efficiency of a standard Python list versus a NumPy `ndarray` when processing 1 million rows of motor speed data.
3. Write a Python function that accepts a raw list of dictionary items representing CAN bus messages `[{'id': '0x101', 'data': '0A1F'}, ...]` and filters out only the messages with ID `0x101`.

4. Given a dictionary containing cell voltages `cells = {'cell1': 3.6, 'cell2': 3.2, 'cell3': 3.7}`, write a Pandas script to convert this dictionary into a Data Frame and add a new column calculating the deviation of each cell from the average voltage.

UNIT II TELEMETRY DATA PREPROCESSING & CLEANING 9 hours

Data Quality Assessment: Identifying missing values, noisy sensor signals, and duplicate timestamps in fleet data. Imputation Techniques: Linear and forward-fill interpolation for continuous vehicle signals (e.g., speed, current). Outlier Detection: Isolating voltage spikes, sensor drops, and anomalous thermal readings using statistical bounds. Time-Series Alignment: Resampling irregular sensor frequencies to uniform intervals (e.g., converting 10Hz data to 1Hz). Cleaning a corrupted battery log dataset by filtering out sensor noise and imputing missing temperature metrics.

Experiments:

1. In an EV fleet, a vehicle enters an underground tunnel and loses cellular connectivity for 5 minutes. Discuss the risks of using forward-fill (`ffill`) interpolation versus linear interpolation to recover the missing GPS and battery temperature data during this blind spot.
2. What is an Isolation Forest, and why is it preferred over simple standard deviation thresholds for detecting multivariate anomalies (e.g., simultaneous high current and low voltage)?
3. A Pandas Data Frame `df` has a `battery_temp` column. Write a script to detect and replace outliers (defined as values 3 standard deviations away from the mean) with the median temperature of the dataset.
4. Vehicle log A records data at 10Hz, while log B records at 1Hz. Write a Python snippet using Pandas `resample()` to downsample log A to match the 1-second interval of log B, aggregating using the mean value

UNIT III EXPLORATORY DATA ANALYSIS (EDA) & EV VISUALIZATION 9 hours

Statistical Summaries: Descriptive statistics of drive cycles, regenerative braking efficiency, and state of charge (SoC). Visualization with Matplotlib & Seaborn: Line plots, scatter plots, histograms, and heatmaps for vehicle metrics. EV Specific Plots: Plotting Voltage vs. SoC curves, thermal runaway indicators, and power distribution profiles. Geospatial Analytics: Introduction to plotting vehicle GPS coordinates and tracking fleet routes using Folium. Hands-on Lab: Building a visual dashboard to analyze the relationship between motor temperature, ambient temperature, and driving speed.

Experiments:

1. Describe what a "Voltage vs. State of Charge (SoC)" open-circuit voltage curve looks like for a Lithium-Iron-Phosphate (LFP) battery versus a Nickel-Manganese-Cobalt (NMC) battery. Why is EDA crucial to identify these differences?
2. Explain how a heatmap can be used to visualize thermal gradients across a 96-cell battery pack module.
3. Write a Matplotlib script to plot a dual-axis graph. The X-axis should represent `Time`. The left Y-axis should show `Vehicle_Speed` (line plot), and the right Y-axis should show `Motor_Current` (scatter plot).

UNIT IV PREDICTIVE MODELING & REGRESSION FOR EV PERFORMANCE 9 hours

Statistical Foundations: Correlation analysis, hypothesis testing, and variance calculation in fleet testing. Energy Consumption Modeling: Implementing Linear and Multiple Regression to predict range based on driving behaviour and terrain. Battery Degradation Prediction: Estimating State of Health (SoH) and Remaining Useful Life (RUL) using Scikit-Learn. Model Evaluation: Tuning hyperparameters and calculating metrics like Mean Squared Error (MSE) and R-squared. Building a regression pipeline to predict the remaining driving range of an EV based on current battery status.

Experiments:

1. Why does a simple linear regression model fail to accurately predict EV driving range when a vehicle transitions from flat highway driving to steep hilly terrain? Which additional features should be included in a multiple linear regression model?
2. Define State of Health (SoH) and Remaining Useful Life (RUL) of a battery. What evaluation metrics (e.g., RMSE, R^2) would you use to validate an RUL prediction model?
3. Using `sklearn.linear_model.LinearRegression`, write a Python pipeline to split an EV dataset into 80% training and 20% testing sets. Train the model to predict `Energy_Consumed_kWh` using `Distance_Traveled` and `Average_Speed`.
4. Write a script to calculate and print the Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) between an array of actual battery capacity values `y_true` and predicted capacities `y_pred`.

UNIT V MACHINE LEARNING FOR FLEET TELEMATICS & VEHICLE DIAGNOSTICS 9 hours

Classification for Fault Diagnosis: Using Decision Trees, Random Forests, and K-Nearest Neighbours (KNN) to classify battery cell faults. Unsupervised Learning for Charging Behaviour: Clustering fleet charging patterns (e.g., fast vs. slow charging impacts) using K-Means. Anomaly Detection: Identifying early-stage insulation failures or cell imbalances using isolation forests. Deployment Basics: Saving trained models using Pickle or `Joblib` for edge-computing modules in vehicles. Training a machine learning classifier to flag abnormal cell voltage deviations before a critical battery failure occurs.

Experiments:

1. Explain how a Random Forest classifier handles non-linear relationships when predicting whether a battery pack will experience thermal runaway based on sensor inputs.
2. An EV fleet operator wants to group drivers based on their charging behaviours (e.g., frequent fast-charging vs. overnight slow-charging). Why is K-Means clustering appropriate for this task, and how do you determine the optimal number of clusters k?
3. Using Scikit-Learn, write a complete script to train a Support Vector Machine (SVM) or Random Forest classifier to categorize a battery cell status as `Normal (0)` or `Faulty (1)` using features: `Internal_Resistance` and `Temperature_Rise_Rate`.
4. Write the Python code to save your trained machine learning model to disk using `joblib` and write a separate snippet showing how the vehicle's onboard computer would load this model to make a real-time prediction.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO1: Parse, clean, and align raw CAN bus logs and irregular time-series EV telematics streams using Python.

CO2: Design and interpret specialized engineering visualizations for drive cycles, thermal gradients, and battery degradation profiles.

CO3: Build and validate regression models to forecast real-time EV energy consumption and driving range metrics.

CO4: Implement predictive data workflows to estimate battery State of Health (SoH) and Remaining Useful Life (RUL).

CO5: Deploy machine learning algorithms to automate fleet vehicle fault classification and cluster charging behaviours.

Text Book(s)

1. Python for Data Analysis | Wes McKinney (O'Reilly)
2. *'Data Science for Transport: A Self-Instructional Guide"* by Charles Fox.

Reference Books

1. "Applied Data Science: Lessons Learned for the Data-Driven Business" by Martin Braschler, Thilo Stadelmann, and Kurt Stockinger (Springer).

Mode of Evaluation: Continuous Internal Evaluation , Assignments, Mid Term Tests and End Semester Examination.

Discipline Electives

M. Tech Electric Vehicle Technology

Discipline Elective – I

25MBEVTDC01 ENERGY STORAGE DEVICES AND SYSTEMS

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

The Energy Storage Devices and Systems course explore the principles, technologies, and management of storing energy in various forms. It equips students with the technical knowledge to integrate renewable energy, balance power grids, and support emerging applications like electric vehicles (EVs) and smart microgrids.

Course Objectives:

1. To understand how different electric vehicle type's function.
2. To explain important battery characteristics.
3. To explore the different categories of batteries.
4. To illustrate battery charging and modeling
5. To familiarize students with novel and alternative energy sources.

UNIT I TYPES OF ELECTRIC VEHICLES 9 hours

Battery electric vehicles, The IC engine/electric hybrid vehicle, fueled electric vehicles, Electric vehicles using supply lines, Solar powered vehicles, Electric vehicles which use flywheels or super capacitors, Electric Vehicles for the Future.

UNIT II BATTERY PARAMETERS 9 hours

Electrochemical Batteries, Cell and battery voltages, Charge (or Amp hour) capacity, Energy stored, Specific energy, Energy density, Specific power, Amp hour (or charge) efficiency, Energy efficiency. Self-discharge rates, Battery geometry, Battery temperature, Battery life and number of deep cycles.

UNIT III TYPES OF BATTERIES 9 hours

Lead Acid Batteries, Nickel-based Batteries: Introduction, Nickel cadmium, Nickel metal hydride batteries, Sodium-based Batteries, Lithium Batteries, Metal Air Batteries.

UNIT IV BATTERY CHARGING AND MODELLING 9 hours

Battery Charging, Battery chargers, Charge equalization, The Designer's Choice of Battery, Use of Batteries in Hybrid Vehicles, Internal combustion/battery electric hybrids, Battery/battery electric hybrids, Combinations using flywheels, Complex hybrids, Battery Modelling, the purpose of battery modelling, Battery equivalent circuit, Modelling battery capacity, Simulation a battery at a set power, Calculating the Peukert Coefficient, Approximate battery sizing.

UNIT V ALTERNATIVE AND NOVEL ENERGY SOURCES AND STORES 9 hours

Introduction, Solar Photovoltaic, Wind Power, Flywheels, Ultra capacitors, Super Capacitors, Supply Rails, Hydrogen Fuel Cells: Basic Principles, Hydrogen Storage, I: Storage as Hydrogen, Hydrogen Storage, II: Chemical Methods.

Course Outcomes:

At the end of the course student will be able to

CO1: Determine the different types of electric vehicles and their performance metrics.

CO2: Evaluate the variation of battery parameters during charging and discharging cycles.

CO3: Enumerate battery types and study their performance parameters.

CO4: Analyze battery charging requirements and build a comprehensive battery model.

CO5: Identify novel and alternative energy sources that can be used in EVs.

M. Tech Electric Vehicle Technology

Text Book(s)

1. James Larminie Oxford Brookes University, Oxford, UK John Lowry Acenti Designs Ltd., UK, Electric Vehicle Technology Explained
2. M. Barak (Ed.), T. Dickinson, U. Falk, J.L. Sudworth, H.R. Thirsk, F.L. Tye, "Electrochemical Power Sources: Primary & Secondary Batteries", IEE Energy Series 1, A. Wheaton & Co, Exeter, 1980.
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.

Reference Books

1. T R Crompton, "Battery Reference Book", Reed Educational and Professional Publishing Ltd., 2000.
2. James Larminie and John Lowry, "Electric Vehicle Technology Explained", John Wiley& Sons Ltd., 2003.
3. John Warner, "The Handbook of Lithium-Ion Battery Pack Design", Elsevier Inc.,2015.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech Electric Vehicle Technology

Discipline Elective – I

25MBEVTDC02 BATTERY MANAGEMENT SYSTEM

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

It is an advanced engineering course designed to provide a comprehensive understanding of the hardware architectures, software frameworks, and state-estimation algorithms required to safely and efficiently manage modern electrochemical energy storage systems. This course bridges the gap between battery electrochemistry and real-time embedded control, preparing students to design and deploy robust power solutions for electric vehicles (EVs), grid-scale renewable energy storage, and consumer electronics.

Course Objectives:

The objectives of this course are to:

1. Understand the fundamentals of batteries and energy storage systems used in electric vehicles and renewable energy applications.
2. Learn the architecture, functions, and components of Battery Management Systems (BMS).
3. Analyze battery characteristics, charging/discharging methods, and state estimation techniques.
4. Study battery protection, thermal management, cell balancing, and safety mechanisms.
5. Develop knowledge of BMS communication, control strategies, and real-time applications in electric mobility systems.

UNIT I FUNDAMENTALS OF BATTERIES AND ENERGY STORAGE SYSTEMS 9 hours

Introduction to Energy Storage Systems, Types of Batteries, Lead Acid Batteries, Nickel Metal Hydride Batteries, Lithium-Ion Batteries, Battery Parameters and Characteristics, Charge and Discharge Characteristics, Battery Capacity and Efficiency, Energy Density and Power Density Battery Modelling Basics.

UNIT II FUNDAMENTALS OF BATTERY MANAGEMENT SYSTEMS 9 hours

Introduction to Battery Management Systems, Need for BMS, BMS Architecture, Functional Requirements of BMS, Battery Pack Configuration, Sensors and Data Acquisition Systems Voltage, Current, and Temperature Monitoring, Battery Pack Design Considerations.

UNIT III BATTERY MONITORING AND STATE ESTIMATION 9 hours

State of Charge (SOC) Estimation, State of Health (SOH) Estimation, State of Function (SOF), Coulomb Counting Method, Kalman Filter Techniques, Battery Modelling for Estimation, Battery Diagnostics, Data Logging and Fault Detection.

UNIT IV BATTERY PROTECTION AND THERMAL MANAGEMENT 9 hours

Battery Safety Issues, Overcharging and Deep Discharge Protection, Short Circuit Protection Thermal Runaway, Battery Thermal Management Systems. Air Cooling and Liquid Cooling Techniques, Passive and Active Cell Balancing, Battery Reliability and Safety Standards.

UNIT V BMS APPLICATIONS AND COMMUNICATION SYSTEMS 9 hours

BMS Communication Protocols, CAN Protocol, LIN Protocol, SPI and I2C Interfaces, Embedded Controllers for BMS, BMS in Electric Vehicles, BMS in Renewable Energy Storage Systems, Smart Battery Technologies, IoT-Based Battery Monitoring, Recent Trends and Future Developments in BMS.

M. Tech Electric Vehicle Technology

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1: Explain the fundamentals, characteristics, and classifications of batteries used in energy storage systems.

CO2: Analyze the architecture and operational principles of Battery Management Systems.

CO3: Apply techniques for battery monitoring, State of Charge (SOC), State of Health (SOH), and thermal management.

CO4: Design and evaluate battery protection and cell balancing circuits for safe battery operation.

CO5: Demonstrate knowledge of BMS communication protocols, control strategies, and applications in electric vehicles and renewable energy systems.

Text Book(s)

1. Battery Management Systems by Gregory L. Plett, published by Artech House.
2. Electric Vehicle Technology Explained by James Larminie and John Lowry, published by Wiley.

Reference Books

1. Lithium-Ion Batteries: Fundamentals and Applications edited by Yoshio Nishi, published by Springer.
2. Battery Systems Engineering by Christopher D. Rahn and Chao-Yang Wang, published by Wiley.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – I

25MBEVTDC03 THERMAL MANAGEMENT OF EV SYSTEMS

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

A Thermal Management of EV Systems course focuses on the core principles, simulation, and hardware engineering required to regulate heat in electric vehicles. It teaches students how to maintain optimal temperature ranges for components to maximize safety, battery life, and overall driving range.

Course Objectives:

This course delves into the intricate realm of thermal management in electric vehicles, covering essential concepts such as heat transfer modes, cabin climate control, battery thermal management systems, and advanced cooling technologies. Through theoretical insights, practical applications, and experimental investigations, students will gain a holistic understanding of optimizing thermal performance in the evolving landscape of electric vehicle engineering.

UNIT I HEAT TRANSFER 9 hours

Introduction to heat transfer- modes of heat transfer- basic laws of heat transfer-importance of various thermo-physical properties- combined heat transfer mechanism. One-dimensional steady state heat conduction – analysis of plane wall, cylindrical and spherical configurations - thermal resistance- critical radius-conduction with heat generation. Transient conduction. Convection heat transfer: Newton's law of cooling-Laminar and Turbulent flow- Free and forced convection for internal and external configurations- Importance of various non- dimensional numbers.

UNIT II COOLING TECHNOLOGIES 9 hours

Fins and Heat Sinks: 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, Advanced Cooling Technologies in EVs: Heat Pipe Applications in Electronic Cooling, Thermosyphons, Liquid Cooling. Phase Change Materials.

UNIT III THERMAL COMFORT 9 hours

Cabin Climate Control: Definition of Thermal Comfort, Human Thermo-Physiology, Body Energy Balance, Skin Sensible Losses and Latent Losses, Respiratory Losses. Vehicle Indoor Climate - Mean Radiant Temperature, Operative Temperature, Equivalent Temperature, Local and Whole-Body Equivalent Temperature. Control of Vehicle Indoor Climate and Air Stratification. Evaluation of Thermal Comfort - PMV Approach, Cabin Thermal Loads- Energy Transfer Mechanisms Involved in a Vehicle Cabin, Heat Transfer Through the Cabin Body - Heat Transfer Through the Glazing. Ventilation – Internal Gains, HVAC Unit Components and Working Principle, Working Principle of a Vapor-Compression Refrigerator - Integration of the Air-Conditioning Loop into the Vehicle.

UNIT IV BATTERY THERMAL MANAGEMENT SYSTEMS 9 hours

Battery thermal management systems: Liquid cooling systems, Air cooling systems, Phase change materials (PCM) and their role in thermal management. Comparison of different thermal management approaches, Thermal issues associated with lithium-ion batteries. Factors influencing battery temperature. Strategies for battery thermal management: active cooling, passive cooling, and thermal insulation. Future BTM Technologies. Thermal modeling and simulation techniques for predicting battery temperature distribution. Case studies of battery thermal management systems implemented in commercial electric vehicles.

UNIT V BATTERY TMS 9 hours

Simulation and Experimental Investigation of Battery TMSs: Numerical Model Development for Cell and Submodules, Numerical Study of PCM Application, Initial and Boundary Conditions and Model Assumptions, Material Properties and Model Input Parameters, Governing Equations and Constitutive Laws, Model Development for Simulations. Simulations and Experimentations on Cell Level, Submodule Level. Instrumentation of the Cell, Submodule, Heat Exchanger. Preparation of PCMs and Nano-Particle Mixtures. Setting up the Test Bench. Vehicle Level Experimentation Set Up and Procedure- Setting Up the Data Acquisition Hardware and Software. Vehicle Level Experimentations.

Course Outcomes:

At the end of the course student will be able to

CO1: Analyze steady-state and transient conduction, evaluate convective processes, and understand non-dimensional numbers' significance.

CO2: Comprehend fin equations, heat sink design, and advanced cooling technologies, applying them effectively in electric vehicle thermal management.

CO3: Understand thermal comfort, vehicle indoor climate, HVAC principles, and integration of air conditioning systems in vehicle cabins.

CO4: Apply battery thermal management techniques, understand thermal issues, and predict temperature distribution using modeling, preparing for future technologies.

CO5: Develop numerical models, conduct simulations and experiments, and set up vehicle-level experimentation for battery thermal management systems.

Text Book(s)

1. Dincer, I., Hamut, H.S. and Javani, N., 2016. Thermal management of electric vehicle battery systems. John Wiley & Sons.
2. Bergman, T.L., Lavine, A.S., Incropera, F.P. and DeWitt, D.P., 2011. Introduction to heat transfer. John Wiley & Sons.

Reference Books

1. Lemort, Vincent, Gérard Olivier, and Georges de Pelsemaeker. Thermal Energy Management in Vehicles. John Wiley & Sons, 2023.
2. Younes Shabany," Heat Transfer: Thermal Management of Electronics" 2010, CRC Press.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – I

25MBEVTDC04 CONTROL SYSTEMS FOR ELECTRIC VEHICLE

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course covers the fundamentals and advanced applications of control systems engineered specifically for electric mobility platforms. It bridges the gap between classic control theory and real-time automotive execution. Students dive deep into the mathematical system modeling, hardware architectures, and algorithmic frameworks necessary to run a modern EV efficiently.

Course Objectives:

The objectives of this course are to:

1. Master advanced linear and state-space control methods tailored specifically to electrified drivetrains.
2. Formulate multi-domain dynamic models representing EV powertrain components, batteries, and tire-to-road physics.
3. Design state-of-the-art energy management and field-weakening control algorithms to maximize range and battery longevity.
4. Synthesize digital control routines within the Electronic Control Unit (ECU) framework utilizing software platforms.
5. Analyze vehicle performance under drivetrain fault conditions to deploy stable, fail-safe mechanisms.

UNIT I INTRODUCTION TO SYSTEM MODELLING 9 hours

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 SYSTEM SIMULATION AND VALIDATION 9 hours

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 MODEL BASED CONTROL APPROACH FOR ELECTRIC VEHICLE 9 hours

Introduction to P, PI & PID Controller, and Internal Model Control (IMC) Design, Introduction to Model based control system design for Electric Vehicle.

UNIT IV STATE SPACE REPRESENTATION 9 hours

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 STABILITY ASPECTS OF CONTROL SYSTEMS 9 hours

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.

Course Outcomes:

At the end of the course student will be able to

CO1: Formulate mathematical models for longitudinal, vertical, and lateral electric vehicle dynamics based on standard control architectures and system classifications.

CO2: Execute multi-domain simulations of electrical and mechanical systems using Software-in-the-Loop (SIL) and Hardware-in-the-Loop (HIL) validation methodologies.

CO3: Design classical P, PI, PID, and Internal Model Control (IMC) strategies specifically tailored for modern electric vehicle architectures.

CO4: Analyze multi-variable systems by constructing canonical state-space representations and synthesizing pole-placement state feedback controllers and observers.

CO5: Evaluate absolute system stability using Lyapunov criteria to safely deploy traction, power steering, and active vehicle control applications.

Text Book(s)

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

Reference Books

1. Wuwei Chen, Hansong Xiao, Qidong Wang, Linfeng Zhao and Maofei Zhu, Integrated Vehicle Dynamics and Control, Wiley, First Edition 2016.
2. Hui Zhang and Dongpu Cao and Haiping Du, Modelling, Dynamics and Control of Electrified Vehicles, WP Publishing, Elsevier 2018.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – II

25MBEVTDC05 AUTOMOTIVE ENGINEERING

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces the engineering foundations of the automobile with emphasis on vehicle architecture, chassis systems, powertrain, body engineering, electrical subsystems, safety, performance, and EV-oriented automotive integration.

Course Objectives:

1. To understand the major subsystems of an automobile including chassis, body, powertrain, steering, suspension, braking, and electrical systems.
2. To study vehicle dynamics, automotive body engineering, and performance-related design principles.
3. To analyze automotive electrical and electronic systems relevant to modern electric vehicles.
4. To examine safety, emission, thermal, and standards-related aspects of automotive engineering.
5. To build a foundation for advanced EV systems, diagnostics, and automotive integration.

UNIT I INTRODUCTION TO AUTOMOTIVE SYSTEMS 9 hours

Automotive evolution and classifications; layout of conventional, hybrid, and electric vehicles; major automotive subsystems; fundamentals of automotive systems; vehicle architecture and functional requirements.

UNIT II CHASSIS, STEERING, SUSPENSION AND BRAKES 9 hours

Automotive chassis and frame; steering geometry and steering mechanisms; suspension systems and ride characteristics; braking systems and performance; tires, wheels, and road interaction.

UNIT III POWERTRAIN AND TRANSMISSION SYSTEMS 9 hours

IC engine overview for baseline comparison; clutch, gearbox, propeller shaft, differential and axle; automotive transmission systems; integration of electric prime movers and driveline elements in EVs.

UNIT IV BODY ENGINEERING, NVH AND THERMAL SYSTEMS 9 hours

Automotive body engineering concepts; body structures and materials; vehicle aerodynamics; noise, vibration and harshness; HVAC and thermal management in automotive applications.

UNIT V AUTOMOTIVE ELECTRICALS, SAFETY AND STANDARDS 9 hours

Automotive electrical systems; sensors and actuators; wiring, protection devices and control interfaces; automotive safety requirements, standards, and testing considerations with relevance to electric vehicles.

Course Outcomes:

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

CO1: Explain the construction and operation of major automotive subsystems.
CO2: Analyze chassis, steering, suspension, and braking characteristics of vehicles.
CO3: Evaluate powertrain and transmission layouts for conventional and electric vehicles.
CO4: Assess body engineering, NVH, thermal, and electrical aspects of automotive design.
CO5: Apply safety and standards knowledge in automotive and EV engineering contexts.

Text Book(s)

1. David A. Crolla, *Automotive Engineering: Powertrain, Chassis System and Vehicle Body*.
2. Reimpell, Stoll and Betzler, *The Automotive Chassis: Engineering Principles*.

Reference Books

1. Joseph Heitner, *Automotive Mechanics*.
2. Robert Bosch GmbH, *Bosch Automotive Electrics and Automotive Electronics*.
3. Tom Denton, *Automotive Electrical and Electronic Systems*.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – II

25MBEVTDC06 SPECIAL ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

The course Special Electrical Machines provides an in-depth understanding of advanced, non-conventional electric motors and generators used in specialized industrial and commercial applications. Students will explore the construction, operating principles, torque generation, and control strategies of advanced machines that go beyond traditional DC, induction, or standard synchronous motors. This course is essential for engineering fields like robotics, mechatronics, electric vehicles, and precision position control systems.

Course Objectives:

The objectives of the course are to make the students learn about:

1. Modeling and control strategies of Permanent Magnet Synchronous Machines used in EV traction systems.
2. Dynamic analysis and control of Permanent Magnet Brushless DC motor drives.
3. Converter configurations and sensorless control techniques of Switched Reluctance Motors.
4. Operating principles and control strategies of stepper motors and their applications.
5. Performance and applications of linear electric machines in transportation and levitation systems.

UNIT I PERMANENT MAGNET SYNCHRONOUS MACHINE AND CONTROL STRATEGIES **9 hours**

PMSM modeling, rotor reference frame transformation, unbalanced operation, zero sequence inductance, electromagnetic torque, steady-state torque characteristics, equivalent circuits, dynamic simulation, vector control and control strategies.

UNIT II PERMANENT MAGNET BRUSHLESS DC MACHINES AND THEIR CONTROL **9 hours**

PMBLDC motor construction, mathematical modeling, normalized equations, drive schemes, commutation torque ripple, phase advancing, dynamic modeling, split supply converter topology and operational modes.

UNIT III SWITCHED RELUCTANCE MOTOR (SRM) AND CONVERTERS **9 hours**

SRM construction and working principle, torque production, converter circuits, current regulation, rotor position sensing, microprocessor-based control, sensorless control, Converter Configurations, Single-Switch-per-Phase Converters, (q+1) Switch and Diode Configurations, Comparison of Some Power Converters, Two-Stage Power Converter, Resonant Converter Circuits, Control of SRM Drive, Control Principle, Closed-Loop, Speed-Controlled SRM Drive.

UNIT IV STEPPER MOTORS AND CONTROL STRATEGIES **9 hours**

Variable reluctance stepper motors, permanent magnet stepper motors, hybrid stepper motors, step angle, drive circuits, micro-stepping, open-loop and closed-loop control strategies and applications.

UNIT V LINEAR ELECTRIC MACHINES 9 hours

Linear induction motors, linear synchronous motors, linear DC motors, linear reluctance motors, levitation machines, thrust equations, performance analysis, electromagnetic launchers and transportation applications.

Course Outcomes:

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

CO1: Analyze PMSM models and advanced control strategies used in EV propulsion systems.

CO2: Evaluate the performance and control of PM brushless DC motor drives for electric vehicle applications.

CO3: Analyze SRM converter configurations and control techniques including sensorless operation.

CO4: Explain the operation and control strategies of stepper motors and their industrial applications.

CO5: Assess the performance and applications of various linear electric machines in transportation and levitation systems.

Text Book(s)

1. T.J.E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Oxford University Press.
2. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press.

Reference Books

1. Ion Boldea, *Electric Drives*, CRC Press.
2. B.K. Bose, *Modern Power Electronics and AC Drives*, Pearson.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech Electric Vehicle Technology

Discipline Elective-II

25MBEVTDC07 OPERATIONAL RESEARCH

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

It is an advanced analytical course designed to equip students with mathematical modeling techniques and optimization algorithms to solve complex decision-making problems. The course focuses on converting real-world organizational challenges in logistics, finance, manufacturing, and healthcare into structured mathematical models to find the most efficient, cost-effective solutions.

Course Objectives:

The objectives of this course are to:

1. Formulate optimization problems mathematically.
2. Apply OR techniques for engineering and managerial decision-making.
3. Solve transportation, assignment, inventory, and scheduling problems.
4. Analyze project management networks using CPM and PERT.
5. Develop analytical and problem-solving skills aligned with OBE standards.

UNIT I INTRODUCTION & LINEAR PROGRAMMING 9 hours

Introduction to Operations Research, Scope, Applications, and Limitations, Mathematical Modelling, Linear Programming Problem (LPP), Formulation of LPP, Graphical Method, Simplex Method, Big-M Method, Two-Phase Method, Duality Concept.

UNIT II TRANSPORTATION & ASSIGNMENT MODELS 9 hours

Transportation Problem Formulation, Initial Basic Feasible Solution, North-West Corner Method, Least Cost Method, Vogel's Approximation Method (VAM) MODI Method, Assignment Problems, Hungarian Method, Travelling Salesman Problem (Basics), Sequencing Problems.

UNIT III NETWORK ANALYSIS & PROJECT MANAGEMENT 9 hours

Network Models, CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), Project Scheduling, Crashing, Resource Allocation, Shortest Path Problems, Minimal Spanning Tree.

UNIT IV INVENTORY & QUEUING THEORY 9 hours

Inventory Control Models, EOQ (Economic Order Quantity), Inventory Models with Shortage, Probabilistic Inventory Models, Queuing Theory Basics, Single Server Models, Multi-Server Models, Poisson Distribution, Exponential Service Time.

UNIT V ADVANCED OR TECHNIQUES 9 hours

Dynamic Programming, Game Theory, Replacement Models, Decision Theory, Simulation Techniques, Markov Analysis (optional), Integer Programming.

M. Tech Electric Vehicle Technology

Course Outcomes:

After successful completion of the course, the student will be able to:

CO1: Formulate real-world engineering and management problems into mathematical models.

CO2: Analyze and solve transportation, assignment, sequencing, and network problems.

CO3: Apply CPM and PERT techniques for project scheduling, monitoring, and optimization.

CO4: Develop inventory and queuing models to improve decision-making in production.

CO5: Use advanced OR techniques such as dynamic programming and game theory

Text Book(s)

1. Operations Research by Hamdy A. Taha, published by Pearson Education, 10th Edition.
2. Introduction to Operations Research by Frederick S. Hillier and Gerald J. Lieberman, published by McGraw Hill Education, 10th Edition.

Reference Books

1. Principles of Operations Research by Harvey M. Wagner, published by Prentice Hall of India.
2. Linear Programming and Network Flows by Mokhtar S. Bazaraa, John J. Jarvis, and Hanif D. Sherali, published by Wiley India.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – II

25MBEVTDC08 VEHICLE MANAGEMENT AND CONTROL

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course explores the electronic architectures, control systems, and software frameworks that govern modern conventional, hybrid, and electric vehicles. Students learn how Electronic Control Units (ECUs) process sensor data to optimize powertrain efficiency, manage battery energy, and regulate active safety features like ABS and electronic stability control. The curriculum bridges the gap between automotive hardware and intelligent software, preparing students to design and troubleshoot the interconnected systems of next-generation autonomous and electric transportation.

Course Objectives:

The objectives of this course are to:

1. Understand control system logic across conventional internal combustion engines, hybrid networks, and battery electric vehicles.
2. Apply vehicular communication protocols like CAN, LIN, and Flex Ray to establish reliable data sharing between vehicle components.
3. Design and evaluate algorithms for active safety features, including adaptive cruise control and collision avoidance systems.
4. Develop strategic power distribution models to improve vehicle efficiency, thermal management, and battery longevity.
5. Interpret On-Board Diagnostics (OBD) data architectures to monitor vehicle health and isolate electronic faults.

UNIT I EV, HEV AND POWER TRAIN 9 hours

1 phase and 3 phase AC analog control, 1 phase and 3 phase AC digital control, battery pack passive balancing, DC-DC converter, automatic transmission, Battery control unit, DC fast charging, drive line components, electric power steering, fuel cell control unit, sensors in power train, Block diagram of VCU, Virtual engine sound system.

UNIT II ADVANCED DRIVER ASSISTANT SYSTEMS (ADAS) 9 hours

ADAS domain controller, automotive thermal camera, camera module without processing, conditionally automated drive controller, drive assist ECU, Drive monitoring, LiDAR.

UNIT III BODY ELECTRONICS AND LIGHTING 9 hours

Automotive HVAC compressor Module, Automotive HVAC control module, Automotive HVAC sensors, Automotive gateway, heater module, Body control module, DC/AC inverter, door handle module, gesturing, headlight, Interior Light, Obstacle detection sensor, power distribution box, rear light, wiper module, sliding door module, smart glass module, seat comfort module, passive entry passive start.

UNIT IV MOTOR CONTROL AND DRIVE 9 hours

Motor types: ACIM control, Brushed DC motor Control, PMSM control, Stepper Motor control, Switched reluctance Motor control.

UNIT V INFOTAINMENT AND CLUSTER, DISPLAY, TIMING AND SYNCHRONIZATION **9 hours**

Head unit, audio amplifiers, telematics, USB media Hub, wireless charging. Graphical user interface, Human machine interface for diagnostic tools. Navigation, secure position and synchronization.

Course Outcomes:

At the end of the course student will be able to

CO1: Comprehend the basics of power train modules in EV and HEV

CO2: Recognize the electronically controlled system used in advanced driver assistance system.

CO3: Identify the body electronics and lighting requirement for EV.

CO4: Select the type of motors and control system for EV application.

CO5: Recognize the need of infotainment, display and synchronization for effective automated transport system.

Text Book(s)

1. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach by Amir Khajepour, M. Saber Fallah, and Avesta Goodarzi.
2. Vehicle Dynamics and Control by Rajesh Rajamani.
3. Hybrid Electric Vehicles: Energy Management Strategies by Simona Onori, Lorenzo Serrao, and Giorgio Rizzoni.

Reference Books

1. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi.
2. Automotive Embedded Systems Handbook by Nicolas Navet and Francoise Simonot-Lion.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech Electric Vehicle Technology

Discipline Elective – III

25MBEVTDC09 LIFE-CYCLE ANALYSIS FOR EV

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:
This course introduces the concepts, methodologies, and applications of Life Cycle Analysis (LCA) for Electric Vehicles (EVs). The course focuses on environmental impact assessment, battery life cycle, resource utilization, sustainability evaluation, recycling methods, and comparative analysis of EVs and conventional vehicles. Students will gain exposure to LCA tools and real-world EV sustainability case studies.

Course Objectives:

1. To understand the principles and methodology of Life Cycle Assessment (LCA).
2. To analyze environmental impacts associated with EV manufacturing and operation.
3. To study battery life cycle, recycling, and circular economy approaches.
4. To evaluate the sustainability and energy efficiency of EV systems.
5. To explore LCA software tools and case studies for EV applications.

UNIT I INTRODUCTION TO LIFE CYCLE ASSESSMENT 9 hours
Concept of sustainability and green mobility, introduction to Electric Vehicles, fundamentals of Life Cycle Assessment (LCA), goal and scope definition, functional unit, system boundaries, cradle-to-grave and cradle-to-cradle approaches, ISO 14040 and ISO 14044 standards.

UNIT II LIFE CYCLE ANALYSIS OF EV COMPONENTS 9 hours
Raw material extraction and processing, rare earth materials, environmental impact of EV manufacturing, electric motors, power electronics, drivetrain systems, battery manufacturing process, carbon footprint analysis, supply chain sustainability.

UNIT III BATTERY LIFE CYCLE AND RECYCLING 9 hours
Lithium-ion battery technologies, battery degradation mechanisms, battery aging, thermal management impact, second-life applications, battery recycling methods such as pyrometallurgical, hydrometallurgical, and direct recycling, circular economy concepts, and e-waste management.

UNIT IV ENVIRONMENTAL AND ECONOMIC ASSESSMENT 9 hours
Greenhouse gas emissions analysis, well-to-wheel and tank-to-wheel analysis, energy consumption, grid dependency, comparison of EVs with ICE vehicles and hybrid vehicles, life cycle costing, carbon credits, policy impacts and sustainability metrics.

UNIT V LCA TOOLS AND FUTURE TRENDS 9 hours
Introduction to LCA tools such as OpenLCA, GaBi and SimaPro, data collection and modelling techniques, sensitivity and uncertainty analysis, EV sustainability case studies, hydrogen mobility, fuel-cell vehicle assessment and future trends in sustainable transportation.

M. Tech Electric Vehicle Technology

Course Outcomes:

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

CO1: Understand the principles and framework of Life Cycle Assessment for EVs.

CO2: Analyse environmental impacts associated with EV components and manufacturing.

CO3: Evaluate battery life cycle, recycling methods, and sustainability approaches.

CO4: Compare economic and environmental performance of EVs and conventional vehicles.

CO5: Apply LCA tools and methodologies for EV sustainability studies.CO5: Understand security and advanced IoT-enabled EV systems.

Text Book(s)

1. Maria E. Triantafyllopoulou, Life Cycle Assessment in the Automotive Sector, Springer
2. Mehrdad Ehsani, Modern Electric, Hybrid Electric and Fuel Cell Vehicles, CRC Press

Reference Books

1. Gregory A. Keoleian, Life Cycle Assessment Handbook, CRC Press
2. James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley.
3. NPTEL Course Material on Electric Vehicles and Sustainability

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – III

25MBEVTDC10 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

It is an advanced electrical engineering course (typically offered at the senior undergraduate or postgraduate level) that focuses on the mathematical representation, transient simulation, and dynamic behavior of electric motors and generators. Unlike introductory courses that focus primarily on steady-state operations, this subject prepares students to analyze how machines behave during sudden changes, such as faults, starting conditions, and speed variations.

Course Objectives:

The objectives of the course are to make the students learn about:

1. Basic concepts of electrical machine modeling and reference frame transformations.
2. Mathematical modeling and transient analysis of DC machines.
3. Dynamic modeling and performance analysis of three phase induction machines.
4. Modeling and per unit analysis of single phase and three phase transformers.
5. Modeling and analysis of synchronous machines using Park's transformation.

UNIT I BASIC CONCEPTS OF MODELING AND REFERENCE FRAME WORKS 9 hours

Primitive machine representation, Kron's primitive machine, voltage and torque equations, two-phase induction machine model, reference frame transformation, three-phase to two-phase transformation and power equivalence.

UNIT II DC MACHINE MODELING 9 hours

Mathematical modeling of DC motors, steady state and transient analysis, inertia load application, transfer function, DC series and shunt motor models and linearization techniques.

UNIT III DYNAMIC MODELING OF THREE PHASE INDUCTION MACHINE 9 hours

Generalized machine model, arbitrary reference frame theory, electromagnetic torque, stator reference frame model, rotor reference frame model, synchronously rotating reference frame model, flux linkage equations and per unit model.

UNIT IV TRANSFORMER MODELING 9 hours

Single phase transformer model, three phase transformer connections, per phase analysis, per unit normalization, change of base, per unit analysis and regulating transformers.

UNIT V MODELING OF SYNCHRONOUS MACHINES 9 hours

Voltage and torque equations, arbitrary reference frame variables, rotor reference frame model, Park's equations, torque equations, rotor angle analysis and per unit system.

M. Tech Electric Vehicle Technology

Course Outcomes:

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

CO1: Apply reference frame transformations and generalized machine modeling concepts.

CO2: Analyze steady state and transient behaviour of DC machines using mathematical models.

CO3: Develop dynamic models of three phase induction machines in different reference frames.

CO4: Perform per unit analysis and modeling of transformer systems.

CO5: Analyze synchronous machine models using Park's equations and reference frame theory.

Text Book(s)

1. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", 2ndEdition, Wiley(India),2010.

Reference Books

1. Arthur R Bergen and Vijay Vittal, "Power System Analysis", 2nd Edition, Pearson, 2009.
2. Chee-MunOng, "Dynamic Simulation of Electric Machinery using Matlab /Simulink",Prentice Hall, 1998.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – III

25MBEVTDC11 BATTERY CHARGING INFRASTRUCTURE

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

It is a specialized engineering and technology course (commonly offered as an elective, certification, or minor program in electric mobility) that covers the design, architecture, communication protocols, and grid integration of electric vehicle supply equipment (EVSE). The course focuses on how energy is safely and efficiently transferred from the electric grid into an electric vehicle's battery pack.

Course Objectives:

The objectives of the course are to make the students learn about:

1. Classify EVSE architectures including AC charging, DC fast charging, and wireless power transfer.
2. Design power electronics converters for high-efficiency on-board and off-board charging stations.
3. Implement global communication protocols such as OCPP and ISO 15118 for secure data exchanges.
4. Evaluate power quality impacts of large-scale EV charging on the local electrical grid.
5. Develop smart charging strategies including Vehicle-to-Grid (V2G) bidirectional energy flow systems.

UNIT I INTRODUCTION TO EV CHARGING AND STANDARDIZATION 9 hours

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 AC-DC POWER CONVERTERS AND GRID INTERFACE 9 hours

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 HIGH-FREQUENCY DC-DC CONVERTERS FOR EV CHARGING 9 hours

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 EV-EVSE COMMUNICATION PROTOCOLS AND CHARGER TESTING 9 hours

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 EMI/EMC COMPLIANCE AND INDUSTRIAL CASE STUDIES 9 hours

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.

M. Tech Electric Vehicle Technology

Course Outcomes:

At the end of the course, the 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.

Text Book(s)

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

Reference Books

1. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India. 2012
2. Mohan N., Underland T.M. and Robbins W.P., "Power Electronics – Converters, Applications and Design",3rd Ed., Wiley India. 2008
3. Christoph Marscholik and Peter Subke, "Road Vehicles - Diagnostic Communication" University Science Press 2009
4. Wolfhard Lawrenz, "CAN System Engineering: From Theory to Practical Applications", Springer. 2013

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

M. Tech Electric Vehicle Technology

Discipline Elective-III

25MBEVTDC12 EV STANDARDS AND TESTING

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course provides a comprehensive engineering and regulatory overview of the global and national frameworks governing electric vehicle (EV) design, manufacturing, safety, and deployment. As the automotive industry shifts toward sustainable mobility, adherence to rigorous testing methodologies and strict regulatory standards is critical to ensure vehicle safety, inter-operability, and commercial compliance.

Course Objectives:

This course enables students to:

1. Understand and interpret diverse international and national standards (e.g., ISO, IEC, SAE, AIS) specific to electric and hybrid vehicles.
2. Evaluate the structural, functional, and electrical powertrain safety requirements necessary to prevent operational hazards.
3. Analyze the protocols, grid integration compliance, and standardization of EV charging interfaces and HEV technologies.
4. Formulate and implement type-testing procedures for assessing electric vehicle performance, battery safety, and component reliability.
5. Examine the technical, safety, and legal standards required for converting internal combustion engine (ICE) vehicles into certified EVs.

UNIT I EV STANDARDS 9 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 30minute power, CMVR type approval for electric power train vehicles, ISO 26262

UNIT II CHARGER AND HEV STANDARD 9 hours

Electric Vehicle Conductive AC Charging System, Electric Vehicle Conductive DC Charging System. 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 9 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 9 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 9 hours

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

M. Tech Electric Vehicle Technology

Course Outcomes:

At the end of the course student 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

Text Book(s)

1. Automotive Industry Standards, India, 2015-2016

Reference Books

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

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – IV

25MBEVTDC13 AUTOMOTIVE SECURITY

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course deals with security issues in connected and software-defined automotive systems, including automotive networks, connected vehicle communication, EV communication interfaces, cybersecurity threats, data attacks, intrusion scenarios, and AI-enabled security solutions.

Course Objectives:

The objectives of the course are to make the students learn about:

1. To understand the need for cybersecurity in modern connected and electric vehicles.
2. To study automotive networking and communication interfaces such as CAN, LIN, and telematics links from a security perspective.
3. To analyze threats, vulnerabilities, attacks, and intrusion mechanisms in automotive and EV communication systems.
4. To examine security protocols, key management, and protection techniques for vehicular and sensor networks.
5. To explore advanced approaches including AI-based security for connected vehicle ecosystems.

UNIT I FOUNDATIONS OF AUTOMOTIVE CYBERSECURITY 9 hours

Introduction to automotive electronics and connected vehicles; security goals; threat landscape in software-defined and connected automobiles; security requirements for EV and intelligent transportation environments.

UNIT II AUTOMOTIVE NETWORKS AND ATTACK SURFACE 9 hours

Automotive networking concepts; CAN, LIN and related communication interfaces; vehicle connectivity, telematics and IoT links; exposure of in-vehicle and vehicle-to-external communication systems to cyber threats.

UNIT III THREATS, ATTACKS AND VULNERABILITY ANALYSIS 9 hours

Cyber security challenges in plug-in electric vehicle communications; data attacks and intrusions in PEV communications; attack vectors in ad hoc and sensor-network-based vehicular systems; vulnerability analysis and risk assessment.

UNIT IV SECURITY PROTOCOLS AND PROTECTION MECHANISMS 9 hours

Security in ad hoc and sensor networks; key distribution and key management; software-based security mechanisms; network security protocols; intrusion detection and secure communication approaches for automotive systems.

UNIT V AI FOR VEHICLE CONNECTIVITY AND CYBERSECURITY **9 hours**

AI for vehicle communication security; AI-based security solutions; intelligent monitoring of connected vehicles; emerging standards and future trends in automotive cybersecurity.

Course Outcomes:

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

CO1: Explain the cybersecurity requirements of connected and electric vehicles.

CO2: Analyze automotive communication networks from a security perspective.

CO3: Identify common attacks and vulnerabilities in vehicular and EV communication systems.

CO4: Evaluate security protocols and protection mechanisms for automotive applications.

CO5: Assess AI-enabled and emerging approaches for automotive cybersecurity.

Text Book(s)

1. Tom Denton, *Automotive Electrical and Electronic Systems*.
2. Erdal Çayırcı and Chunming Rong, *Security in Wireless Ad Hoc and Sensor Networks*.

Reference Books

1. William B. Ribbens, *Understanding Automotive Electronics*.
2. Relevant standards and published material on cyber security of plug-in electric vehicles in smart grids, as listed in the EV syllabus sources.
3. NPTEL course material on fundamentals of automotive systems and vehicle cybersecurity-related topics where adopted by the Programme.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – IV

25MBEVTDC14 AUTOMOTIVE ELECTRONICS

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces automotive instrumentation, sensors, actuators, and control systems used in modern vehicles. It focuses on electronic measurement systems, MEMS-based sensors, intelligent braking, hybrid vehicle transmission systems, and vehicle automation technologies. The course also covers automotive control strategies for engine management, ABS, cruise control, and hybrid vehicles. Diagnostic techniques, IoT-enabled condition monitoring.

Course Objectives:

The objectives of the course are to make the students learn about:

1. To understand the fundamentals of automotive instrumentation and electronic measurement systems used in vehicles.
2. To study the operation and applications of automotive actuators and transmission mechatronic systems.
3. To analyze various automotive sensors and MEMS technologies used in vehicle monitoring and control.
4. To examine vehicle control systems for engine management, braking, transmission, and hybrid vehicles.
5. To learn automotive diagnostic techniques, fault detection methods, and IoT-enabled monitoring systems.

UNIT I AUTOMOTIVE INSTRUMENTATION 9 hours

The system approach to control and Instrumentation, electronic fundamentals, I/O signal flows and conversions, Multiplexing, fuel quantity measurement, coolant temperature measurement, oil pressure measurement, vehicle speed measurement, display devices and intelligent glass cockpit, Engine management system, ABS, Computer controlled dampers.

UNIT II AUTOMOTIVE ACTUATORS AND TRANSMISSION SYSTEMS 9 hours

Actuator operations, Actuator for fuel injectors, gas circulation, idle speed control, ABS actuators, electronic unit injectors, Piezo electric energy harvesters, Transmission mechatronics system for electric hybrid vehicle 4 Wheel and 2 Wheel drives, Steer by wire and intelligent braking.

UNIT III AUTOMOTIVE SENSORS AND MEMS SYSTEMS 9 hours

Electromagnetic sensors, optical sensors, combustion knock sensors, variable resistance type sensors, pressure sensing, temperature sensors, ride height control sensors, manifold absolute pressure sensor, exhaust gas oxygen sensor, air low sensors, accelerometers and other sensors for steering by wire.

UNIT IV VEHICLE CONTROL SYSTEMS 9 hours

Air fuel control, spark timing control, transmission control, clutch for awd, hybrid vehicles control, series parallel split hybrid and feedback based supervisory control, cruise control, ABS control and control for fuel systems.

UNIT V AUTOMOTIVE SYSTEM DIAGNOSTICS 9 hours

Circuit testing, six step approach, fault finding and emission related systems, ignition systems, sensor system and intermittent fault diagnostic systems, Intelligent collaborative diagnostic systems, IOT enabled conation monitoring and diagnostic systems.

Course Outcomes:

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

CO1: Explain the working principles of automotive instrumentation and electronic control systems.
CO2: Analyze the operation of automotive actuators in modern vehicles.
CO3: Evaluate automotive sensors and MEMS devices used for vehicle safety and performance.
CO4: Apply control strategies for automotive subsystems such as ABS and hybrid vehicle systems.
CO5: Diagnose automotive system faults using intelligent and IoT-enabled diagnostic techniques.

Text Book(s)

1. W. B. Ribbens, 2017, Understanding Automotive electronics, Butterworth–Heinemann ISBN - 07506-7008-8.
2. A. Bonnick, 2001, Automotive computer-controlled systems, Butterworth–Heinemann ISBN - 07506-50893.

Reference Books

1. Uwe. K, L. Nielsen, 2005, Automotive control system, Springer, ISBN-354023139-0
2. W. Bolton, 2019, Mechatronics, Electronics, Control systems in Mechanical Engineering, Pearson Education ltd, ISBN 013121633
3. T. Denton, 2016, Routleg publisher, Advanced Automotive Fault Diagnosis: Automotive Technology: Vehicle Maintenance and Repair, ISBN 978-0415725767

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – IV

25MBEVTDC15 COMPUTER VISION

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces the fundamental concepts of Image Processing, Computer Vision, and Computer Graphics, focusing on techniques for acquiring, analyzing, and interpreting visual information. It covers image formation models, feature extraction, motion estimation, segmentation, and object recognition methods. The course also explores advanced topics such as 3D reconstruction, face recognition, surveillance, and autonomous vehicle vision systems.

Course Objectives:

The objectives of the course are to make the students learn about:

1. To understand the fundamentals of image processing, computer vision, computer graphics, and their diverse real-world applications.
2. To analyze image formation processes, camera models, projection techniques, and 3D scene reconstruction methods.
3. To apply image pre-processing, feature extraction, stereo vision, and motion estimation techniques for visual data analysis.
4. To understand shape representation, image segmentation, deformable models, and object recognition techniques.
5. To explore pattern recognition, face analysis, surveillance systems, and intelligent transportation applications using computer vision techniques.

UNIT I INTRODUCTION 9 hours

Image Processing, Computer Vision and Computer Graphics, What is Computer Vision - Low-level, Mid-level, High-level, Overview of Diverse Computer Vision Applications: Document Image, Analysis, Bio-metrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, Virtual Reality and Augmented Reality.

UNIT II IMAGE FORMATION MODELS 9 hours

Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration, Binocular imaging systems, Multiple views geometry, Structure determination, shape from shading, Photometric Stereo, Depth from Defocus, Construction of 3D model from images.

UNIT III IMAGE PROCESSING, FEATURE EXTRACTION, AND MOTION ESTIMATION 9 hours

Image pre-processing, Image representations (continuous and discrete), Edge detection, Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion.

UNIT IV SHAPE REPRESENTATION AND SEGMENTATION 9 hours

Contour based representation, Region based representation, De-formable curves and surfaces, Snakes and active contours, Level set representations, Fourier, and wavelet descriptors, Medial representations, multi-resolution analysis, Object recognition.

UNIT V IMAGE UNDERSTANDING AND COMPUTER VISION APPLICATIONS **9 hours**

Pattern recognition methods, Face detection, Face recognition, 3D shape models of faces Application: Surveillance – foreground-background separation –human gait analysis Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians.

Course Outcomes:

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

CO1: Understand the fundamentals of computer vision, image processing, and computer graphics.
CO2: Analyze image formation models and apply camera geometry concepts for 3D scene.
CO3: Apply image processing and feature extraction techniques for structure-from-motion analysis.
CO4: Demonstrate the ability to represent, segment, and recognize objects using contour, region, and deformable model-based approaches.
CO5: Develop knowledge of image understanding techniques and analyze computer vision applications such as face recognition, surveillance, and intelligent transportation systems.

Text Book(s)

1. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall
2. Richard Szeliski, Computer Vision: Algorithms and Applications (CVAA), Springer, 2010

Reference Books

1. E. R. Davies, Computer & Machine Vision, Academic Press, 2012
2. Dana H. Ballard, Christopher M. Brown, Computer Vision, Prentice Hall 1st Edition (May 1, 1982), ISBN-978-0131653160

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.

Discipline Elective – IV

25MBEVTDC16 INTERNET OF THINGS FOR ELECTRIC VEHICLE APPLICATION

L	T	P	C
3	0	0	3

Pre-requisite Nil

Course Description:

This course introduces IoT concepts and their applications in electric vehicle systems including connected vehicles, battery monitoring, telematics, smart charging, and vehicle-to-grid communication.

Course Objectives:

The objectives of the course are to make the students learn about:

1. To understand IoT architecture for EV applications.
2. To analyse connected EV communication protocols.
3. To study cloud-based EV monitoring systems.
4. To implement smart charging and energy management techniques.
5. To explore cybersecurity issues in connected EVs.

UNIT I INTRODUCTION TO IOT AND EV SYSTEMS 9 hours

Introduction to Internet of Things (IoT), characteristics and enabling technologies of IoT, IoT architecture and layered models, physical and logical design of IoT systems, sensors and actuators used in EV applications, embedded systems and microcontrollers for connected vehicles, cloud computing fundamentals, edge computing concepts, overview of electric vehicle architecture, connected EV ecosystem, intelligent transportation systems, role of IoT in electric mobility, data acquisition systems and smart sensing technologies for EVs.

UNIT II COMMUNICATION TECHNOLOGIES FOR EVS 9 hours

Communication requirements in electric vehicles, wired and wireless communication protocols, Controller Area Network (CAN), LIN, FlexRay, Ethernet-based automotive communication systems, Bluetooth, ZigBee, Wi-Fi, MQTT and CoAP protocols, GSM, LTE and 5G communication technologies for connected EVs, IoT gateways, edge devices, vehicle-to-vehicle (V2V), vehicle-to-grid (V2G), vehicle-to-home (V2H) and vehicle-to-infrastructure (V2I) communication systems, cloud-based communication architecture for EV systems.

UNIT III SMART BATTERY AND VEHICLE MONITORING 9 hours

Battery Management Systems (BMS), battery monitoring architecture, State of Charge (SOC) estimation methods, State of Health (SOH) estimation techniques, thermal monitoring and protection systems, battery balancing methods, IoT-enabled battery analytics, data logging and remote monitoring systems, predictive maintenance concepts, vehicle telematics, GPS-based tracking systems, cloud analytics for EV diagnostics, fault detection and condition monitoring techniques in connected electric vehicles.

UNIT IV SMART CHARGING AND ENERGY MANAGEMENT 9 hours

EV charging technologies and standards, charging station architecture and communication systems, AC and DC fast charging methods, wireless charging techniques, smart charging infrastructure, demand response management, renewable energy integration with EV charging stations, energy optimization strategies, energy scheduling techniques, cloud-based charging management systems, smart grid interaction, load balancing techniques, vehicle-to-grid (V2G) operation and grid support applications of EVs.

UNIT V SECURITY AND ADVANCED EV APPLICATIONS 9 hours

Cybersecurity challenges in connected EV systems, authentication and encryption techniques, secure communication protocols, privacy and data protection in IoT-enabled EV systems, blockchain applications in EV networks, artificial intelligence and machine learning applications in EV monitoring and diagnostics, autonomous and connected electric vehicles, intelligent fleet management systems, predictive analytics, digital twin technology for EV systems, future trends and challenges in IoT-enabled electric mobility.

Course Outcomes:

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

CO1: Understand IoT architecture for EV applications.

CO2: Analyse communication systems in connected EVs.

CO3: Develop smart monitoring solutions for EV batteries.

CO4: Evaluate smart charging and V2G technologies.

CO5: Understand security and advanced IoT-enabled EV systems.

Text Book(s)

1. Arshdeep Bahga and Vijay Madisetti, Internet of Things – A Hands-on Approach.
2. Raj Kamal, Internet of Things: Architecture and Design Principles.

Reference Books

1. Perry Lea, Internet of Things for Architects.
2. Mehrdad Ehsani, Modern Electric, Hybrid and Fuel Cell Vehicles.
3. NPTEL Course Material on IoT and EV Applications.

Mode of Evaluation: Assignments, Mid Term Tests and End Semester Examination.