VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE (VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Two Year Postgraduate Programme
Leading to Master of Technology
(M. Tech.) Degree in Electric
Vehicle Technology

Implemented from the batch admitted in Academic Year 2025-26

Mechanical Engineering with specialization in Electric Vehicle Technology

Program Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems in Automobile Engineering and Electric Vehicles.

PO2: An ability to write and present a substantial technical report/document in the area of Electric Vehicle Technology.

PO3: Students should be able to demonstrate a degree of mastery in the area of Automobile Engineering and Electric Vehicle Technology. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

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In

Electric Vehicle Technology

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M.Tech. in Electric Vehicle Technology

Scheme of Instruction and Evaluation

SEMESTER I

Scheme of Instruction					**Scheme of Evaluation**			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MEEV5001T	Computational Methods	3-0-0	3	20	30	50	3
2.	MEEV5011S	Automotive Systems and Body Engineering	3-0-0	3	20	30	50	3
3.	MEEV5012S	Advance Automotive Prime Movers	3-0-0	3	20	30	50	3
4.		Programme elective 1	3-1-0	4	20	30	50	3
5.		Programme elective 2	3-1-0	4	20	30	50	3
6.		Open elective 1	3-0-0	3	20	30	50	3
7.	MEEV5071L	Laboratory 1- Computational Methods Lab	0-0-2	1	60%CIE		40	-
8.	MEEV5072L	Laboratory 2 - Automotive System	0-0-2	1	60%CIE		40	-
9.	MEEV5073L	Laboratory 3 - EV simulation laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE			-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

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SEMESTER II

Scheme of Instruction					**Scheme of Evaluation**			
Sr. No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1.	MEEV5002S	Research Methodology and IPR	3-0-0	3	20	30	50	3
2.	MEEV5013S	Vehicle Dynamics	3-1-0	4	20	30	50	3
3.	MEEV5014S	Hybrid and Electric Vehicles	3-1-0	4	20	30	50	3
4.		Programme elective 3	3-0-0	3	20	30	50	3
5.		Programme elective 4	3-0-0	3	20	30	50	3
6.		Open elective 2	3-0-0	3	20	30	50	3
7.	MEEV5074L	Laboratory 4: Automotive Electricals and Battery Management	0-0-2	1	60%CIE		40	-
8.	MEEV5075L	Laboratory 5: Advance Composite Material Laboratory	0-0-2	1	60%CIE		40	-
9.	MEEV5076L	Laboratory 6: Advanced Finite Element Analysis Laboratory	0-0-2	1	60%CIE		40	-
10.		Liberal Learning	0-0-2	1	100%CIE			-
			28	24				

abbreviations **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination, **CIE** Continuous In-semester Evaluation

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List of Programme Elective 1

Sr. No.	Course Code	Course Title
1	MEEV5021S	Energy storage systems for EV
2	MEEV5022S	EV Charging Systems

List of Programme Elective 2

Sr. No.	Course Code	Course Name
1	MEEV5031S	Automotive Aerodynamics
2	MEEV5032S	Advanced Automobile Transmission System

List of Programme Elective 3

Sr. No.	Course Code	Course Name
1	MEEV5041S	Automotive Electricals and Battery Management
2	MEEV5042S	Design and Controls of EV motors

List of Programme Elective 4

Sr. No.	Course Code	Course Name
1	MEEV5051S	Automotive Noise Vibration and Harshness
2	MEEV5052S	Chassis and Body Design for EVs

List of Open Elective 1

Sr. No.	Course Code	Course Title
1	MEEV5061S	Future Vehicles and Green Technologies

List of Open Elective 2

Sr. No.	Course Code	Course Title
1	MEEV5062S	Design of Energy-Efficient Powertrain Components

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SEMESTER III

Scheme of Instruction					**Scheme of Evaluation**
Sr. No	Course Code	Course Title	L-T-P	Credits	
1.	MEEV5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2.	MEEV5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3.		Self- Learning Course - 1	1-0-0	1	100% ESE of 3 hours or credit transfer
4.		Self- Learning Course - 2	1-0-0	1	100% ESE of 3 hours or credit transfer
5.		Mandatory Non-Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
				12	

SEMESTER IV

Scheme of Instruction					**Scheme of Evaluation**
S. No	Course Code	Course Title	L-T-P	Credits	
1.	MEEV5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2.	MEEV5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

SEMESTER-I

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5001T**
Course Title	**Computational Methods**

Course Outcomes

After completion of course, students would be able to

1. solve algebraic equations, Eigen value problems
2. analyze data using interpolation and regression methods.
3. solve ordinary and partial differential equations using numerical techniques

Course Contents

Unit 1: Introduction

Engineering problems and computational methods; Introduction to numerical methods and analysis.

Unit 2: Error Analysis

Approximations; Round-off and Truncation errors; Backward and Forward error analysis

Unit 3: Roots of Nonlinear Equations

Bisection method, Regula Falsi, Secant method, Fixed point Method; Newton-Raphson method; Multiple roots; Roots of system of non-linear equations; Analysis and order of convergence; Polynomials Mueller's method, Bairstow's method**.**

Unit 4: Solution of System of Linear Equations

Direct methods (Gauss Elimination, Gauss-Jordan, LU decomposition, Thomas Algorithm); Perturbation analyses of direct methods matrix and vector norms, condition number of matrix; Iterative methods (Jacobi and Gauss-Seidel); convergence criteria for Jacobi and Gauss Seidel iterative methods, rate of convergence of iterative methods. Successive over Relaxation.

Unit 5: Solution of System of Nonlinear Equations

Iterative methods, Fixed Point iteration, Newton-Raphson method.

Unit 6: Approximation of functions

Approximation using polynomials (Simple, least squares estimation, orthogonal basis functions, Tchebycheff and Legendre polynomials); Interpolation (Newton's divided difference and Lagrange interpolating polynomials, Spline interpolation); Regression

Unit 7: Eigen values and Eigen vectors

Power, inverse power, and inverse power method with shift, Fadeev-Leverrier method for the formulation of the Characteristic polynomials and QR decomposition

Unit 8: Numerical Differentiation

Introduction to finite difference approximations, Derivation of generalized finite difference approximation of any order and accuracy, truncation error analysis, Richardson's extrapolation

Unit 9: Numerical Integration

Newton-Cotes integration formula, Romberg integration and Gauss Legendre quadrature; Ordinary

Unit 10: Ordinary Differential Equations (Initial Value Problems)

Euler's method, multi-step methods, Runge-Kutta methods, Predictor Corrector Methods. Stiff ODEs. System of IVPs, Stiff problems and Gear's method

Unit 11: Ordinary Differential Equations (Boundary Value Problems)

Decomposition into Linear System of ODEs, Shooting and direct methods;
Partial Differential Equations Introduction to solution of PDEs, Parabolic (diffusion equation and advective-diffusion equation), Elliptic (Laplace equation) and Hyperbolic (Wave equation) equations; Explicit and Implicit Methods, Crank Nicholson Method

Recommended Reading

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw Hill
2. Santosh Gupta, Numerical Methods for Engineers, New age international publishers
3. J.B. Doshi, Differential Equations for Scientists and Engineers, Narosa, 2010
4. Kreyszig, Erwin, I.S., Advanced Engineering Mathematics, Wiley, 1999
5. C. F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education Asia, New Delhi, Sixth Edition, 2006.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5011S**
Course Title	**Automotive Systems and Body Engineering**

Course Outcomes

After completion of course, students would be able to

1 outline the structure of the automobile
2 analyze the various forces and torque reaction on front and rear axles.
3 formulate steering, braking and suspension systems.
4 analyze the effects of vibration, noise and ergonomics of the vehicle.
5 evaluate various methods in vehicle body manufacturing

Unit1: Vehicle classifications and specifications and Materials

Current Scenario of the global automobile industry and future challenges in vehicle manufacturing. Vehicle classifications and specifications: Frames, Chassis Layout and Constructional details. Power plant locations and drive. Vehicle body type and layouts, load distribution. Selection of Materials: Aluminum Alloys, CFRP, High-Strength Steel Structural Integrity and Crashworthiness Material Optimization for Weight Reduction and Strength.

Unit 2: Axles, Steering System

Axles: Types of front axles and their constructions, Purpose and materials. Steering System: Steering geometry, Steering requirements, Steering linkages and steering gears, oversteer and understeer, Cornering power, Reversibility of steering gears.

Unit 3 Wheels and Tyres

Wheels and Tyres: Wheels construction, alloy wheel, wheel balancing, types of tyres, construction, materials, factors affecting tyre life.

Unit 4: Brakes and Suspension system

Pneumatic, Electro and vacuum brakes, Disc brakes, Weight transfer during braking and braking efficiency, braking of vehicle front wheel, Rear wheel, ABS, Objectives of suspension, Basic requirements, Springs-Leaf and Coil springs, Air suspension and its features, independent suspension, Sprung and un-sprung mass, Pitching, Rolling and bouncing, Shock absorbers

Unit 5: Transmission and drive line

Requirements of clutches, Types of clutches and clutch materials, Fluid coupling- Gear box-types, Automatic Transmission, Continuously Variable Transmission (CVT), Propeller Shafts, Overdrive, final drive and differential.

Unit 6: Vehicle Ergonomics and Regulations

Driver visibility and passenger seating and controlling arrangements for more safety. CMV (Central Govt. Motor Vehicle acts) rules and regulations.

Recommended Readings:

Kirpal Singh, Automobile Engineering, Vol. 1&2 Standard Publications.
N.K. Giri, Mechanics, Khanna Publishers, New Delhi, 8th Edition
P. S. Kohali, Automobile Electrical Equipment, Tata McGraw Hill Publication.
Reimpell J., ―The automotive chassis: Engineering principle, 2ndEdition, 1983
Vehicle Body Engineering, Powloski J, Business Books Ltd, 2000.
Automotive Body, Volume-I (component design), Lorenzo Morello, Springer, 2013
Automotive Engineering (Power Train, Chassis system and Vehicle Body), David A Crolla, Elsevier collection, 2009.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5012S**
Course Title	**Advance Automotive Prime Movers**

Course Outcomes

After completion of course, students would be able to

1. understand the fundamental of IC Engines and EV motors
2. evaluate the performance parameters
3. compare and select appropriate prime movers
4. analyze electric motors used in Electric vehicle

Unit 1: Fundamentals of Prime Movers

Definition and Classification of Prime Movers Overview of IC Engines and Electric Motors as Prime Movers Energy Sources: Fossil Fuels vs. Electricity (Batteries, Grid, Renewable Sources) Power and Efficiency Concepts in Prime Movers

Unit 2: Internal Combustion Engines (IC Engines) as Prime Movers

Basic Working Principles of IC Engines (SI & CI Engines) Combustion in SI and CI Engines Fuel Injection Systems and Combustion Characteristics Performance Parameters: Power, Torque, Efficiency

Unit 3: Pollutant emissions from IC Engines

Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOX) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Emission norms-EURO and Bharat stage norms.

Unit 4: Emerging Trend in EV prime movers

Hybrid Powertrains, Alternative Fuels, Different types of batteries, next gen motor technology, wireless charging and bidirectional charging

Unit 5: Electric Motors as Prime Movers for EVs

Types of Electric Motors Used in EVs (Induction, BLDC, PMSM) Working Principles and Performance Characteristics Battery and Energy Storage Systems in EVs Regenerative Braking and Energy Management Systems Comparison of IC Engine and Electric Motor Performance

Unit 6: Electric Propulsion unit

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Recommended Reading:

Internal Combustion Engine Fundamentals John B. Heywood (McGraw Hill)
Engineering Fundamentals of IC Engine, W.W. Pulkrabek, PHI Pvt.Ltd 2002 II Edition
Electric vehicle technology explained, John Lowry and James Larmine, John Wiley and Sons, 2012.
Y. Yang and C. Zhang, *"Battery Management System and Control Strategies for EVs"*, Springer, 2021

Programme Elective-I

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5021S**
Course Title	**Energy storage system for EV**

Course Outcomes

After completion of course, students would be able to

1. compare different energy storage technologies and their suitability for EV applications.
2. analyze the performance of Li-ion batteries and understand their limitations.
3. design a battery pack and implement BMS for efficient energy management.
4. evaluate alternative storage solutions like supercapacitors, flywheels, and hydrogen fuel cells.
5. explore innovations in charging infrastructure and sustainability of energy storage systems

Unit 1: Introduction to Energy Storage for EVs (4 Hours)

Overview of EV power train and energy storage requirements Comparison of energy storage technologies (Battery, Ultra-capacitors, Flywheels, Hydrogen Fuel Cells) Performance parameters: Energy density, power density, efficiency, life cycle, and cost.

Unit 2: Electrochemical Energy Storage Systems (6 Hours)

Working principles of Lithium-ion (Li-ion) batteries Battery chemistry: Li-ion, Li-Polymer, Solid-state, Sodium-ion, LFP, NMC, LTO, etc. Thermal characteristics, safety concerns, and degradation mechanisms Battery modeling and equivalent circuit representation, Comparison of different Energy Storage System.

Unit 3: Cells and Batteries (8 Hrs)

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors-Power and energy requirements of batteries-Meeting battery performance criteria-setting new targets for battery performance.

Unit 4: Batteries for Electric Vehicles (8Hrs)

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

Unit 5: Alternative Energy Storage Technologies (6 Hrs)

Supercapacitors: Construction, working, applications in EVs Flywheel Energy Storage (FES): Design, working, energy recovery applications Hydrogen Fuel Cells: Proton Exchange Membrane Fuel Cells (PEMFCs), Hybrid energy storage systems (HESS) Hybrid storage systems: Combining batteries, capacitors, and fuel cells.

Unit 6: Charging Technologies and Infrastructure (6 Hrs)

Overview of charging technologies: AC, DC fast charging, Wireless charging Battery charging methods: CCCV, Pulse charging, Fast charging techniques Grid integration and Vehicle-to-Grid (V2G) concept Standards and regulations (IEC, IEEE, BIS, SAE, UL)

Recommended Reading:

1. J.M. Tarascon and M. Armand, *"Issues and Challenges Facing Rechargeable Lithium Batteries"*, Nature 414, 2001.
2. T. Reddy, *"Linden's Handbook of Batteries"*, 4th Edition, McGraw Hill, 2010.
3. I. Buchmann, *"Batteries in a Portable World"*, Cadex Electronics Inc., 3rd Edition, 2016.
4. J. Larminie and J. Lowry, *"Electric Vehicle Technology Explained"*, Wiley, 2012.
5. Y. Yang and C. Zhang, *"Battery Management System and Control Strategies for EVs"*, Springer, 2021.
6. SAE, IEEE, and IEC standards for EV batteries and charging infrastructure.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5022S**
Course Title	**EV Charging Systems**

Course Outcomes

The student should be able to

1. understand the fundamentals of EV charging
2. analyze charging technologies
3. interpret charging standards and protocols
4. design EV charging infrastructure
5. assess safety and regulatory compliance

Unit 1: Introduction to EV Charging Systems

Basics of Electric Vehicles & Battery Requirements Importance of EV Charging Infrastructure Overview of Charging Levels (Level 1, Level 2, DC Fast Charging) Comparison with Traditional Fueling Systems

Unit 2: Charging Technologies and Architectures

AC vs. DC Charging On-board vs. Off-board Chargers Charging Power Levels and Efficiency Wireless (Inductive) and Battery Swapping Technologies

Unit 3: Charging Standards and Communication Protocols

Global Charging Standards (CCS, CHAdeMO, GB/T, Tesla Superchargers) Open Charge Point Protocol (OCPP) Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) Communication Smart Charging and IoT Integration

Unit 4: EV Charging Infrastructure and Grid Integration

Charging Station Layout and Design Considerations Grid Load Management and Demand Response Renewable Energy Integration (Solar, Wind) Energy Storage Systems in Charging Stations

Unit 5: Safety, Regulations, and Certification

Electrical Safety in Charging Stations Thermal Management and Fire Safety Government Policies and Incentives for EV Charging International and National Regulatory Frameworks

Unit 6: Future Trends and Innovations in EV Charging

Ultra-Fast Charging and Solid-State Batteries Bidirectional Charging and Energy Trading AI and Machine Learning in EV Charging Networks Emerging Business Models in EV Charging Industry

Recommended Readings:

1. James Larminie and John Lowry – Electric Vehicle Technology Explained, Wiley, 2nd Edition, 2012.
2. Iqbal Husain – Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2nd Edition, 2011.
3. Sandeep Dhameja – Electric Vehicle Battery Systems, Newnes, 1st Edition, 2001.

4. Sheldon S. Williamson – Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
5. James M. Gere and Barry J. Goodno – Mechanics of Materials, Cengage Learning, 9th Edition, 2017 (for structural aspects of charging stations).

Programme Elective-II

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5031S**
Course Title	**Automotive Aerodynamics**

Course outcomes:

After completion of course, students would be able to

1. able to predict the drag and lift coefficients in the given case of fluid flow situation
2. able to devise an experiment for carrying out aerodynamic analysis of the vehicle
3. able to carry out numerical simulations by devising a fluid flow problem
4. able to Predict variation in Aerodynamic forces and moments acting on vehicle body with changes in body shape

Course Contents:

Unit 1: Introduction

Scope – historical development trends – Fundamentals of fluid mechanics – Flow phenomenon related to vehicles – External & Internal flow problems – Resistance to vehicle motion – Performance – Fuel consumption and performance – Potential of vehicle aerodynamics.

Unit 2:Aerodynamic Drag of Cabs

Car as a bluff body – Flow field around car – drag force – types of drag force – analysis of aerodynamic drag – drag coefficient of cars – strategies for aerodynamic development – low drag profiles.

Unit 3:Shape Optimization of Cabs

Front and modification – front and rear wind shield angle – Boat tailing – Hatch back, fast back and square back – Dust flow patterns at the rear – Effect of gap configuration – effect of fasteners.

Unit 4:Vehicle Handling

The origin of force and moments on vehicle – side wind problems – methods to calculate forces and moments – vehicle dynamics Under side winds – the effects of forces and moments – Characteristics of forces and moments – Dirt accumulation on the vehicle – wind noise – drag reduction in commercial vehicles.

Unit 5:Wind Tunnels for Automotive Aerodynamic

Introduction – Principles of wind tunnel technology – Limitation of simulation – Stress with scale models – full scale wind tunnels –measurement techniques – Equipment and transducers – road testing methods –Numerical methods.

Recommended Reading

1. Hucho, W.H., Aerodynamics of Road vehicles, Butterworths Co. Ltd., 1997
2. Pope, A, Wind Tunnel Testing, John Wiley & Sons, 2nd Edn., New York, 1994.
3. Automotive Aerodynamics: Update SP-706, SAE, 1987.
4. Vehicle Aerodynamics, SP-1145, SAE, 1996.

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Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5032S**
Course Title	**Advanced Automotive Transmission System**

Course Outcomes:

After completion of course, students would be able to

1. interpret the performance characteristics of various transmission components.
2. evaluate various requirements and components of semi - automatic & automatic transmission systems.
3. analyze the performance of EV transmission systems

Course Contents

Unit 1: Fundamentals of Transmission Systems (6 Hours)
Basic functions and requirements of a transmission system Classification of transmission systems: Manual, Automatic, CVT, DCT, and EV transmissions Torque, power, and efficiency considerations in IC Engine and EVs Recent trends in transmission technology

Unit 2: Manual and Automatic Transmission for IC Engine Vehicles (8 Hours)
Manual Transmission (MT): Components, gear shifting mechanisms, synchronizers Automatic Transmission (AT): Hydrodynamic torque converters, planetary gear sets Continuously Variable Transmission (CVT): Pulley-based and Toroidal CVT, belt and chain CVT Dual Clutch Transmission (DCT): Dry and wet clutch systems, performance comparison electronic control and actuation in automatic transmissions

Unit 3: Transmission System in Electric Vehicles (8 Hours)
Difference between IC Engine and EV transmission requirements Single-speed and multi-speed reduction gears in EVs Role of power electronics and inverters in EV drivetrains Regenerative braking and energy recovery systems direct drive vs. gearbox-based transmission systems in EVs

Unit 4: Hybrid Electric Vehicle (HEV) and (PHEV) Transmissions (8 Hours)
Series, parallel, and power-split hybrid architectures Planetary gear-based hybrid transmissions (e.g., Toyota Hybrid System) E-CVT in hybrid vehicles Integration of electric motors with conventional transmissions Control strategies for power flow optimization in hybrid drivetrains

Unit 5: Advanced and Future Transmission Technologies (6 Hours)
Intelligent and adaptive transmission systems (AI-based transmission control) Wireless power transmission for EVs Advanced materials for lightweight and efficient transmission components Smart drivetrains with AI-based predictive maintenance Vehicle-to-grid (V2G) and bidirectional power flow impact on EV transmission.

Recommended Reading:

1. Andras Z. Szeri, - Fluid film lubrication theory and design,2 nd Edition, 1992.
2. J.G. Giles - Automatic and fluid transmissions,1 st Edition1969.
3. Arthur w. Judge - Modern transmission systems‖,1 st Edition, 1973.
4. Hybrid Electric Vehicles: Principles and Applications – Chris Mi, M. Abul Masrur,
5. Advanced Hybrid Powertrains for Commercial Vehicles– Richard Van Basshuysen

Laboratory Courses
Semester I

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5071L**
Course Title	**Computational Methods Laboratory**

Course Outcomes

After completion of course, students would be able to

1. write codes that use computational methods to numerically solve problems in a variety of disciplines in Mechanical Engineering.
2. learn open-source packages that implement popular computational methods.
3. apply the mathematical concepts the Computational Methods course.

Course Contents

The lab will involve development of programs based on numerical methods using Python/Matlab/Scilab etc. for solving variety of common Mechanical Engineering problems.

1. Program for solving system of linear equations
2. Program for regression analysis and curve / function fitting to a given data set
3. Program for root finding on non-linear equation
4. Program for Numerical Differentiation and Integration
5. Program for solving differential equations based on Runge-Kutta formulation
6. Program for Boundary Value Problems in Ordinary and Partial Differential Equations

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5072L**
Course Title	**Automotive System Laboratory**

Course Outcomes

After completion of course, students would be able to

1. demonstrate an understanding of IC engine components
2. analyze and compare different transmission systems
3. examine steering and suspension systems
4. conduct vehicle performance tests using standard drive cycles

List of experiments (Any 6)

1. Study of IC Engine Components and Working.
2. Transmission System and Gearbox Mechanism
3. Fuel System and Emission Control
4. Braking System and Performance Evaluation
5. Steering and Suspension System Analysis
6. Vehicle Electrical and Electronic Systems
7. Thermal Management and Cooling System of IC Engine
8. Vehicle Performance and Efficiency Analysis

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5073L**
Course Title	**EV simulation Laboratory**

Course Outcome

After completion of course, students would be able to

1. develop and simulate electric vehicle powertrain models.
2. analyze the performance of batteries in EVs, including state-of-charge (SOC) estimation
3. design and simulate power electronic circuits for motor control in electric vehicles.
4. conduct drive cycle analysis to estimate EV range, energy consumption,

List of experiments (Any 6)

1. Introduction to EV Simulation Tools
2. Modeling and Simulation of EV Powertrain
3. Battery Modeling and State-of-Charge (SOC) Estimation
4. Regenerative Braking System Simulation
5. Power Electronics and Motor Control in EVs
6. EV Range Estimation and Drive Cycle Analysis
7. Thermal Management System for EV Battery Packs
8. Energy Management Strategy for Hybrid and Electric Vehicles

Open Elective-I

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5061S**
Course Title	**Future Vehicles and Green Technologies**

Course Outcomes:

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

1. implement the different fuels and their feasibility as automotive fuels.
2. predict and compare the performance characteristics of engine with different alternate fuels.
3. understand the emissions of an engine and their treatment techniques
4. understand the procedure to select a fuel on basis of power output, performance, emission, engine size & applications.
5. understand the measurement principle of emission analyzers.

Course contents:

Unit 1:Emission from Automobiles

Sources of Air Pollution. Various emissions from Automobiles — Formation — Effects of pollutants on environment and human beings. Emission control techniques – Modification of fuel, after treatment devices. Emission standards. Automotive waste management, old vehicle disposal, recycling, tyre recycling.

Unit 2: Alcohols as Fuels

Alternative fuels. Availability of different alternative fuels for engines. Alcohols – Properties, Production methods and usage in engines. Blending, dual fuel operation, surface ignition, spark ignition and oxygenated additives. Performance, combustion and emission Characteristics in engines. Issues & limitation in alcohols.

Unit 3: Bio-Fuels Vegetable Oils

Types of vegetable oils for engine application, Production, esterification, optimization of parameters to maximize the yield of biodiesel, biogas, properties, engine performance and emission characteristics. Vegetable oils and their important properties. Methods of using vegetable oils – Blending, preheating, Trans - esterification and emulsification –Issues & limitation in Vegetable Oils.

Unit 4: Hydrogen as Engine Fuel

Hydrogen – Properties, problems, Production methods, storage and safety aspects. Issues & limitation in Hydrogen. Methods of using hydrogen in engines. Performance, combustion and emission Characteristics in engines.

Unit 5: Fuel Cell: Working principle, classification, description of fuel cell systems, fuel cell components, properties of fuel cell, general performance characteristics, emission characteristics, merits and demerits, vehicle design and layout aspects.

Unit 6 Biogas, Natural Gas and LPG as Fuels

Biogas, Natural gas and LPG – Properties and production methods. CO_2 and H_2S scrubbing in

Biogas, Modifications required for use in Engines- Performance, combustion and emission Characteristics in engines. Issues & limitation in Gaseous fuels.

Unit 7 CNG, LPG & LNG-

Availability, properties, modifications required in SI and CI engines, performance and emission characteristics, storage, handling and dispensing, safety aspects. Bi-Fuel Concept.

Recommended Reading

1. Edward F. Obert, 'Internal combustion engines and air pollution' Harber and Row Publishers, 1973.
2. M. Khovakh, 'Motor Vehicle Engines', Mir Publishers, Mascow,1976
3. W.H. Crouse and A.L. Anglin, 'Automotive Emission Control', McGraw Hill Book Co, 1995.
4. G.S.Springer and A.J. Patterson, 'Engine emissions and pollutant formation', plenum press, Newyork,1986.
5. ARAI & Western Section Proceedings, I C Engine Design & Development, Jan 2009.
6. Ganesan. V, Internal Combustion Engines, Tata McGraw Hill, 1994.
7. Ayhan Demirbas, 'Biodiesel A Realistic Fuel Alternative for Diesel Engines', Springer-Verlag London Limited 2008, ISBN-13: 9781846289941
8. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook, AOCS Press Champaign, Illinois 2005.
9. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers, 1997 ISBN 0-76-80-0052-1.
10. Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.).
11. Science direct Journals (Biomass & Bio energy, Fuels, Energy, Energy conversion Management, Hydrogen Energy, etc.) on biofuels.

SEMESTER-II

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5002S**
Course Title	**Research Methodology and IPR**

Course Outcomes

After completion of course, students would be able to

1. understand research problem formulation and approaches of investigation of solutions for research problems.
2. learn ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes
3. discover importance of Intellectual Property Rights.
4. promote Intellectual Property Right and patenting.

Course Contents

Unit 1: Research Problem

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Literature Review

Effective literature studies approach, analysis, Plagiarism, Research ethics,

Unit 3: Technical Writing

Effective technical writing, how to write report, Paper, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property

Patents, Designs, Trade and Copyright. Process of Patenting and Development technological research, innovation, patenting, development. International Scenario International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR

Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies.

Recommended Reading

1. Ranjit Kumar, Research Methodology A Step by Step Guide for beginners, 2nd Edition
2. C.R. Kothari, Research Methodology Methods and Techniques
3. Halbert, Resisting Intellectual Property, Taylor & Francis Ltd., 2007.
4. Mayall, Industrial Design, McGraw Hill, 1992.
5. Niebel, Product Design, McGraw Hill, 1974.
6. T. Ramappa, Intellectual Property Rights under WTO, S. Chand, 2008

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5013S**
Course Title	**Vehicle Dynamics**

Course Outcomes

After completion of course, students would be able to

1. interpret various forces in static and dynamic conditions.
2. select analytical modeling for various vehicle dynamics systems.
3. study vehicle dynamics, their properties, applications & selection of design parameters.
4. compute effect of various parameters on performance of vehicle systems

Course contents:

Unit 1: Introduction

Terminology-vehicle dynamics, driver, vehicle, load, environment Definition's- reference frame, toe-in, toe-out, wheel camber, design position of wheel axis, steering geometry.

Unit 2: Road

Modeling Aspect Deterministic Profiles-Bump and Potholes, Sine Waves Random Profiles-Statical Properties, Classification of Random Road Profiles, Realizations.

Unit 3: Tire

Introduction- development, composites, forces and torques, measurement, modeling Contact geometry-basic approach, tire deflection, length contact patch, static contact point, contact point velocity, dynamic rolling radius Forces and torques caused by
pressure distribution-wheel load, tipping torque, rolling resistance, Friction forces and torques, First order tire dynamics.

Unit 4: Suspension system

Purpose and Components, Examples, Steering systems, Standard force element,
Dynamic force element.

Unit 5: Vertical dynamics

Goals, Basic tuning, Sky hook damper, Non-linear force element.

Unit 6: Longitudinal dynamics

Dynamic wheel load, Maximum acceleration, Driving and braking, Drive and brake pitch.

Unit 7: Lateral dynamics

kinematic approach, steady state cornering, simple handling model.

Unit 8: Driving behavior of single vehicles

Standard driving maneuvers, coach with different loading conditions, different rear axle concept for passenger car.

Recommended Reading:

1. J. R. Ellis, Vehicle Dynamics, Business Books, London, 1st Edition1969
2. Vehicle dynamics-Dr. Georg Rill, 2ND Edition1992.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5014S**
Course Title	**Hybrid and Electric Vehicles**

Course Outcomes

After completion of course, students would be able to-

1. explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3. analyze various electric drives suitable for hybrid electric vehicles. Evaluate various methods in vehicle body manufacturing.
4. analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.

Course Contents:

Unit 1: Introduction: Sustainable Transportation - Population, Energy, and Transportation - Environment - Economic Growth – Emissions regulations and norms- impact of modern drive- trains on energy supplies-New Fuel Economy Requirement Emergence of Electric Vehicles- Basics of the EV - Constituents of an EV -Vehicle and Propulsion Loads.

Unit 2: HEV Fundamentals: Classification- Hybridization of the Automobile-Mild Hybrids, Full Hybrids, Plug-In Hybrids and Electric Vehicles with Range Extender Hybrids-Architectures of HEVs - Series HEVs Parallel HEVs - Series–Parallel HEVs - Complex HEVs - Diesel and other Hybrids - Other Approaches to Vehicle Hybridization Basics of the HEV- Importance of HEV- Constituents of an HEV –Vehicle Model - Vehicle Performance - HEV Powertrain Component Sizing - Series Hybrid Vehicle - Parallel Hybrid Vehicle - Electrically Peaking Hybrid Concept - Gradeability Requirement -
Selection of Gear Ratio from ICE to Wheel - Wheel Slip Dynamics.

Unit 3: Plug-In Hybrid Electric Vehicles: Basics of Plug-In Hybrid Electric Vehicle (PHEV) - Constituents of a PHEV - Comparison of HEV and PHEV - Basics of Fuel Cell Vehicles (FCVs) - Constituents of a FCV-Some Issues Related to Fuel Cells-Introduction to PHEVs
- PHEVs and EREVs - Blended PHEVs - Electricity for PHEV Use -PHEV Architectures - Equivalent Electric Range of Blended PHEVs - Fuel Economy of PHEVs - Well-to-Wheel Efficiency - PHEV Fuel Economy - Utility Factor - Power Management of PHEVs - Vehicle-to-Grid Technology(V2G) - PHEV Battery Charging - Impact of G2V - The Concept of V2G- Advantages of V2G - Case Studies of V2G.

Unit 4: Electric Machines and Drives in HEVs: Introduction - Induction Motor Drives - Principle of Induction Motors - Equivalent Circuit of Induction Motor - Speed Control of
Induction Machine - Variable Frequency, Variable Voltage Control of Induction Motors -

Efficiency and Losses of Induction Machine - Permanent Magnet Motor Drives - Basic Configuration of PM Motors - Basic Principle and Operation of PM Motors - Unsaturated Motor -Saturated Motor.

Unit 5: Electric Energy Sources and Storage Devices: - Introduction - Characterization of Batteries - Battery Capacity - Energy Stored in a Battery - State of Charge in Battery (SOC) and Measurement of SOC - SOC Determination - Direct Measurement - Amp-hr Based Measurement - Some Better Methods - Initialization Process - Depth of Discharge (DOD)of a Battery - Specific Power and Energy Density - Ampere-Hour (Charge and Discharge) Efficiency - Number of Deep Cycles and Battery Life - Some Practical Issues About Batteries and Battery Life- Battery Management
Implementation - Comparison of Energy Storage Technologies.

Unit 6: Fundamentals of Regenerative Braking: Braking Energy Consumed in Urban Driving - Braking Energy versus Vehicle Speed - Braking Energy versus Braking Power Braking Power versus Vehicle Speed - Braking Energy versus Vehicle Deceleration Rate - Braking Energy on Front and Rear Axles - Brake System of EV, HEV, and FCV.

Unit 7: Special Hybrid Vehicles: Brief Introduction of Hydraulic Hybrid Vehicles - Regenerative
Braking in HHVs-Off-Road HEVs - Hybrid Excavators - Hybrid Excavator Design Considerations - Diesel HEVs Electric or Hybrid Ships- Locomotives.

Recommended Reading:

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018, II Edition.
2. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Chris Mi, M. Abul Masrur John Wiley & Sons, Inc.,2018, II.
3. Electric vehicle technology explained, John Lowry and James Larmine, John Wiley and
4. Sons, 2012.
5. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2003**.**

Online Resources:

1. Introduction to Hybrid and Electric vehicles by Dr. Praveen Kumar and Prof. S. Majhi (IIT Guwahati), NPTEL Course.

(Link: https://nptel.ac.in/courses/108/103/108103009/)

Programme Elective-III

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5041S**
Course Title	**Automotive Electrical and Battery Management**

Course Outcomes:

After completion of course, students would be able to-

1. understand and analyze the key components of automotive electrical systems.
2. evaluate different battery chemistries and their impact on EV performance.
3. design and implement a battery management system for optimal operation.
4. develop fault diagnosis strategies and ensure safe battery operation.
5. explore advanced communication protocols and future trends in BMS technology.

Unit 1: Fundamentals of Automotive Electrical Systems (4 Hours)

Overview of electrical systems in conventional and electric vehicles Wiring harness, fuses, relays, and circuit protection devices Power distribution and energy flow in electric vehicles Role of controllers, sensors, and actuators in EVs

Unit 2: Battery Technology and Characteristics (6 Hours)

Electrochemical fundamentals of Li-ion batteries and alternative chemistries (LFP, NMC, LTO, Solid-state, Sodium-ion, etc.) Performance characteristics: Energy density, power density, efficiency, cycle life, and thermal stability Battery pack design considerations: Series and parallel configurations, interconnections, and thermal management Battery degradation mechanisms and failure modes

Unit 3: Battery Management System (BMS) Architecture (10 Hours)

Importance and functions of BMS in EVs BMS hardware: Microcontrollers, sensors, power electronics, and communication modules Types of BMS: Centralized, Distributed, and Modular BMS architectures SOC (State of Charge), SOH (State of Health), SOP (State of Power), and RUL (Remaining Useful Life) estimation methods

Unit 4: Battery Charging and Protection Strategies (8 Hours)

Battery charging techniques: Constant Current-Constant Voltage (CC-CV), Pulse charging, Fast charging On-board and off-board charging systems Wireless charging and Vehicle-to-Grid (V2G) technology Safety mechanisms: Overcharging, over-discharging, short circuit protection, and thermal runaway prevention

Unit 5: Fault Diagnosis and Thermal Management in BMS (8 Hours)

Fault detection techniques: Model-based and data-driven approaches Diagnostic algorithms: Kalman Filters, Neural Networks, Machine Learning for battery health monitoring Battery Thermal Management Systems

(BTMS): Passive, Active (Air cooling, Liquid cooling, Phase change materials) Fire hazards and emergency shutdown mechanisms in battery packs

Unit 6: Automotive Communication Protocols and Future Trends (4 Hours)

Communication interfaces in BMS: CAN (Controller Area Network), LIN (Local Interconnect Network), SPI, I2C Standard protocols: OBD-II (On-Board Diagnostics), ISO 26262 (Functional Safety), and IEC standards for EV battery safety Future trends: Solid-state batteries, AI-powered battery analytics, Second-life battery applications, and Smart BMS

Recommended Readings

1. T. Reddy, *"Linden's Handbook of Batteries"*, 4th Edition, McGraw Hill, 2010.
2. I. Buchmann, *"Batteries in a Portable World"*, Cadex Electronics Inc., 3rd Edition, 2016.
3. J. Larminie and J. Lowry, *"Electric Vehicle Technology Explained"*, Wiley, 2012.
4. Y. Yang and C. Zhang, *"Battery Management System and Control Strategies for EVs"*, Springer, 2021.
5. H. P. Garg and A. K. Akella, *"Battery Management System for Electric Vehicles"*, CRC Press, 2020.
6. ISO 26262, IEC 62196, and SAE J1772 standards for EV battery safety and charging infrastructure.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5042S**
Course Title	**Design and Controls of EV Motors**

Course Objectives:

After completion of course, students would be able to

1. explain the fundamental principles, operating characteristics, used in EV applications.
2. analyze the design aspects of EV motors,
3. evaluate power electronic interfaces in electric vehicles.
4. assess emerging motor technologies for modern EV applications.
5. investigate real-world EV motor applications

Unit 1: Fundamentals of Electric Motors for EVs (6 hours)

Overview of electric propulsion and motor requirements for EVs. Classification of electric motors: DC motors, Induction motors, PMSM, BLDC motors, SRM. Torque-speed characteristics and efficiency mapping. Design constraints: Power density, efficiency, thermal management.

Unit 2: Motor Design for EV Applications (8 hours)

Electromagnetic design considerations. Selection of materials for motor construction. Rotor and stator design principles. Losses in electric motors and thermal modeling. Cooling techniques for EV motors.

Unit 3: Power Electronics and Motor Control (8 hours)

Role of power electronics in EV motor drives. Inverters for motor drives: Voltage source and current source inverters. PWM techniques and switching strategies. Regenerative braking and energy recovery.

Unit 4: Control Strategies for EV Motors (8 hours)

Open-loop and closed-loop control of motors. Vector control (Field-Oriented Control) of AC motors. Direct Torque Control (DTC) of induction and PMSM motors. AI/ML-based control strategies for real-time optimization.

Unit 5: Advanced Motor Technologies for EVs (6 hours)

High-speed motor designs for EV applications. Wireless power transfer and contactless motor drives. Multi-motor configurations and torque vectoring. Emerging motor technologies: Axial flux motors, dual inverter-fed motors.

Unit 6: Case Studies and Industry Applications (6 hours)

Comparative analysis of EV motor technologies (Tesla, Nissan Leaf, etc.). Integration of motor design with battery and Powertrain. Challenges and future trends in EV motor technology. Software tools for motor design and simulation (MATLAB, ANSYS, JMAG).

Recommended Readings

E. F. Fuhs and M. A. Masoum, *Power Conversion of Renewable Energy Systems*.
N. Mohan, *Electric Motor Drives: Modeling, Analysis, and Control*.
K. T. Chau, *Electric Vehicle Machines and Drives: Design, Analysis and Application*.
S. S. Rao, *Finite Element Methods for Electric Machines and Drives*.
MATLAB/Simulink and ANSYS JMAG Documentation for Motor Simulation.

Programme Elective-IV

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5051S**
Course Title	**Automotive Noise vibration and Harshness**

Course Outcomes:

After completion of course, students would be able to

1. identify sources of noise and vibration in automotive applications
2. understand working of noise & vibration measuring instruments
3. understand the principle of active noise cancellation
4. understand noise control techniques
5. understand signal analysis techniques

Course contents:

Unit 1: NVH in the Automotive Industry

Sources of noise and vibration, design features, common problems, pass-by noise requirements, target vehicles and objective targets, vehicle structure noise, Engine noise, Transmission noise, Exhaust noise

Unit 2: Vibration Theory

Transient and steady state response of one degree of freedom system applied to vehicle systems, transmissibility, modes of vibration.

Unit 3:Basics of Sound

Sound measurement, human sensitivity and weighting factors, combining sound sources, acoustical resonances, properties of acoustic materials.

Unit 4: Test Facilities and Instrumentation

semi-anechoic rooms, Silent room, Modal Analysis, Data Acquisition system, Sound pressure level measurements, microphone, accelerometers, sound sources, Impedance tube, Transmission loss measurement, Sound absorption coefficient measurement, etc. Transducers, signal conditioning.

Unit 5: Signal Processing

Sampling, aliasing and resolution. Statistical analysis, frequency analysis, Campbell's plots, cascade diagrams, coherence and correlation functions.

Unit 6: NVH control Strategies & comfort

Source ranking, noise path analysis, modal analysis, vibration absorbers and Helmholtz resonators, active noise control techniques.

Recommended Reading

1. Noise and Vibration Control, Munjal, M.L. USA World Scientific Publishing Co. Pvt.Ltd.,2013.
2. Noise and vibration control engineering - principles and applications Ver, Istvanl, USA John Wiley & Sons, 2006.
3. Handbook of noise and vibration control Crocker, Malcolm J., Crocker, Malcolm J., USA John Wiley & sons, 2007.
4. Vehicle noise and vibration refinement Wang, Xu, Wang, Xu, USA Woodland Publishing Limited, 2010
5. Active control of noise and vibration, Hansen, Colin; Snyder, Scott; New York CRC PRESS,2013
6. Fundamentals of noise and vibration analysis for engineers, Norton Michael, Norton Michael, USA Cambridge University Press, 2nd ed., 2003
7. Vehicle refinement controlling noise and vibration in road vehicles (Book For PGA Students) SAE R-364 Harrison, Mattew, USA SAE.

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5052S**
Course Title	**Chassis and Body Design for EVs**

Course Outcomes:

At the completion of course students should be able to

1. evaluate material properties for lightweight and high-strength EV structures.
2. design chassis structures considering safety, aerodynamics, and load distribution.
3. assess the impact of battery integration on vehicle structure and safety.
4. recommend suitable manufacturing and testing techniques for EV body and chassis.

Unit 1: Introduction to Electric Vehicle Design

Overview of Electric Vehicle Architecture Differences in Design Approach: ICE vs. EV Importance of Lightweight Structures in EVs Regulatory and Safety Standards for EV Body and Chassis

Unit 2: Materials for EV Body and Chassis

Selection of Materials: Aluminum Alloys, CFRP, High-Strength Steel Structural Integrity and Crashworthiness Material Optimization for Weight Reduction and Strength Sustainability and Recycling of EV Body Components

Unit 3: Chassis Design for EVs

Types of Chassis: Ladder, Monocoque, and Space frame for EVs Design Considerations for Battery Placementin Chassis Crash Safety and Impact Energy Absorption Integration of Suspension and Steering with EV Chassis Modular Chassis Design for Different EV Configurations

Unit 4: Aerodynamics and Structural Analysis

Fundamentals of Vehicle Aerodynamics Role of Aerodynamic Efficiency in EV Range Optimization Computational Fluid Dynamics (CFD) for EV Body Design Structural Simulation and Finite Element Analysis (FEA) of EV Chassis

Unit 5: Battery Pack Integration in Vehicle Structure

Structural Design Considerations for Battery Housing Battery Mounting and Cooling Strategies Crash Protection for Battery Pack Fire Safety and Thermal Management of EV Chassis

Unit 6: Body and Chassis Manufacturing Technologies

Advanced Manufacturing Techniques: Hydroforming, 3D Printing, and Laser Welding Joining Techniques: Adhesive Bonding, Riveting, and Spot Welding Cost Optimization and Mass Production Strategies Smart Manufacturing and AI in EV Body & Chassis Production

Recommended Reading:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2011.
2. Tom Denton, Electric and Hybrid Vehicles, Routledge, 2020.
3. John Fenton, Vehicle Body Layout and Analysis, Mechanical Engineering Publications, 1980.
4. Jason Rowe (Ed.), Advanced Materials in Automotive Engineering, Woodhead Publishing, 2012.

Laboratory Courses
Semester II

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5074L**
Course Title	**Automotive Electrical & Battery Management Laboratory**

Course Outcome

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

1. understand and Analyze Battery Characteristics
2. design and Implement Battery Management Systems (BMS)
3. estimate and Monitor State of Charge (SOC) and Battery Health
4. understand Thermal Management in EV Batteries

List of Experiment (Any 6)

1. Battery Charge/Discharge Cycle and Efficiency Testing
2. Battery Capacity and State of Charge (SOC) Estimation
3. Design and Implementation of a Battery Management System (BMS)
4. Charging and Discharging Characteristics of EV Batteries
5. Design of an Electric Vehicle Powertrain System
6. Regenerative Braking System in Electric Vehicles
7. DC-DC Converter Design for Battery Charging in EVs

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5075L**
Course Title	**Advanced Composite Materials Laboratory**

Course Outcomes

After completion of the course students will be able to

1. develop composite manufacturing process for the given part
2. evaluate the performance of composite structure
3. design the optimal composite structure

List of experiments

1. Resin Preparation and cure cycle
2. Manufacture of composite material using hand layup process
3. Manufacture of natural fibers composite materials
4. Open mold composite manufacturing process
5. Vacuum assisted resin transfer molding process
6. Manufacture of sandwich composite
7. Testing of polymeric composite materials
8. Finite element analysis of composite materials
9. Design optimization of composite structure
10. Manufacture of electrospun nanofibers reinforced composites

Text Books

1. P.K. Mallick, Fiber-Reinforced Composites Materials, Manufacturing, and Design, CRC Press, Third Edition, 2007
2. ANSYS Composite PrepPost User's Guide, http//www.ansys.com

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5076L**
Course Title	**Advanced Finite Element Analysis Laboratory**

Course Outcomes

After completion of course, students would be able to

1. acquire basic understanding of Modeling and Analysis software ·
2. use the commercial Finite Element packages to build and solve selected problems.
3. understand the different kinds of static analysis, find out the stress and other related parameters.
4. learn to apply the basic principles to carry out dynamic analysis.

List of Experiments/Assignments

1. 1-D Element Problems –Linear Static Analysis
2. 2-D Element Problems – Linear Static Analysis
3. 3-D Element Problems – Linear Static Analysis
4. Free Vibration Analysis on Beam, Bars, Plates
5. Non-Linear Analysis of 1-D Element Problems Like Beams, Bars
   Thermal Analysis (Conduction, Convection and Insulation Boundary Conditions.
6. 1-D Element Problems-Steady state And Transient Analysis
7. 2-D Element Problems of Homogeneous and Composite Slap in Steady State and Transient Analysis
8. 3-D Element Problems Steady State Analysis
9. Project-Creating or Importing and Map Meshing of 3-D component /Assembly of practical application and FEA Analysis of Same component /Assembly

Recommended Reading

1. Finite Element Analysis using Ansys 11.0 by Paleti Shrinivas, Krisha Chaitnay Sambana, Rajesh Kumar Datti.
2. Finite Element Analysis Theory and Applications with ANSYS by Saeed Moaveni
3. Engineering Analysis with ANSYS Software by Y. Nakasone and S. Yoshimoto
4. The finite element method And applications in Engineering using Ansys® by Erdogan Madenci, Ibrahim Guven
5. Practical Finite Element Analysis by Nitin Gokhale of M/S Finite to Infinite.
6. Reference Manual of Hypermesh Software
7. Online Tutorial HyperMesh Software
8. Tutorial of Ansys Software.

Open Elective-II

Programme Name	***Masters of Technology in Electric Vehicle Technology***
Course Code	**MEEV5062S**
Course Title	**Design of Energy-Efficient Powertrain Components**

Course Outcomes:

After completion of course, students would be able to

1. understand Energy Losses and Efficiency Metrics
2. design and Optimize Powertrain Components
3. apply Advanced Materials for Lightweight Powertrains
4. implement Powertrain Control Strategies for Optimization.

Unit 1: Introduction to Energy-Efficient Powertrains

Evolution of vehicle powertrains: IC engine, hybrid, and electric powertrains Energy losses in conventional and electric powertrains Efficiency metrics: Energy density, power density, and thermal efficiency Regulatory standards and sustainability concerns

Unit 2: Powertrain Architecture and Component Design

Layout of powertrain components (motor, battery, inverter, gearbox, etc.) Selection of motors: PMSM, BLDC, Induction motors Transmission and drivetrain optimization Role of power electronics in improving efficiency

Unit 3: Lightweight and Advanced Materials

High-strength steel, aluminum, and composite materials for powertrain design Material selection for energy-efficient components Structural optimization and fatigue life estimation Case studies on lightweight electric powertrains

Unit 4: Aerodynamic Optimization for Energy Efficiency

Influence of aerodynamics on powertrain efficiency Computational Fluid Dynamics (CFD) for vehicle design Drag reduction techniques and active aerodynamics Design case studies for aerodynamically efficient EVs

Unit 5: Powertrain Control and Optimization Techniques

Energy management strategies for HEVs and EVs AI and ML-based optimization for energy-efficient powertrains Model predictive control for powertrain efficiency Real-time monitoring and adaptive control systems

Unit 6: Case Studies and Industry Trends

Tesla, Toyota, and BMW case studies on energy-efficient powertrains Future trends in powertrain design (solid-state batteries, hydrogen fuel cells) Emerging technologies in vehicle electrification

Recommended Reading:

1. "Electric and Hybrid Vehicles: Design Fundamentals" – Iqbal Husain
2. "Automotive Power Transmission Systems" – Yi Zhang & Chris Mi
3. "Battery Management Systems for Large Lithium-Ion Battery Packs" – Davide Andrea
4. "Aerodynamics of Road Vehicles" – Wolf-Heinrich Hucho
5. Research papers and case studies from SAE, IEEE, and Elsevier journals