Savitribai Phule Pune University, Pune

Maharashtra, India

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern) in

ME- Mechanical (Electric Vehicle Technology)

(With effect from Academic Year 2026-27)

Preface by Board of Studies

Dear Students and Teachers,

We, the members of the Board of Studies – Mechanical Engineering, are very happy to present First Year Master of Mechanical Engineering (Electric Vehicle Technology) Syllabus effective from the Academic Year 2025-26 (2025 Pattern).

Mechanical Engineering is a dynamic discipline that integrates principles from core engineering fields and supports innovation across manufacturing, design, energy, materials, and industrial automation. This curriculum is designed to provide students with a comprehensive understanding of the fundamentals, emerging technologies, and practical applications of Electric Vehicle Technology in particular and Mechanical Engineering in general. This is also equipping them to meet the demands of a rapidly evolving automobile manufacturing industry.

The curriculum is mainly focused on knowledge component, skill-based activities, experiential learning and project based activities. The syllabus falls in line with the objectives of Savitribai Phule Pune University, AICTE New Delhi, UGC New Delhi, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Dr. Pradeep A. Patil
Chairman
Board of Studies - Mechanical Engineering

Program Educational Objectives

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

PEO	PEO Statements
PEO1	To develop students' ability to formulate, analyze and solve complex engineering problems.
PEO2	To inculcate the skills and knowledge for addressing real-world engineering challenges through design practices, to contribute effectively to multidisciplinary teams and to adapt to technological advancements.
PEO3	To prepare for advanced studies or research in related fields, fostering a commitment to lifelong learning and professional development

Program Objectives (PO)

POs are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, analytical ability attitude and behavior that students acquire through the program. The POs essentially indicate what the students can do from subject-wise knowledge acquired by them during the program. As such, POs define the professional profile of a graduate of PG Engineering Program. NBA has defined the following three POs for a graduate of PG Engineering Program:

PO	PO Statements
PO1	An ability to independently carry out research / investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical Report / document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

General Rules and Guidelines

1. The dissertation stage I and II must result into the publication of at least two research papers (at Stage–I and Stage-II respectively) preferably in the Journal having Citation Index 2.0 and ISSN number; or paper can be published in reputed International Journal recommended by the guide of the Dissertation and the BoS supported PGCON event for paper presentation and participation. The guides certificate covering originality of the work and plagiarism-testing result shall be included in the report along with the Published Journal Papers and PGCON paper presentation and participation certificates. The comments received by the journal paper reviewers be attached in the Dissertation report and shall be made available during dissertation presentation / viva to the examiners.

2. Assessments consist of A) CCE (Comprehensive Continuous Evaluation) and B) End-semester Assessment. Both shall have an approximately equal weightage.

3. Simulation & Modeling Lab and CAD and Structural Design Lab:

This laboratory work will be based on the completion of assignments confined to the courses of the respective semester.

4. SEMINAR:

The student shall deliver the seminar on a topic approved by authorities.

Seminar I: It shall be on state-of-the-art topic of student's own choice approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Seminar II: It shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

Seminar III: It shall be extension of seminar II. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned Guide and head of the department/institute.

5. **PROJECT WORK:**
The project work shall be based on the knowledge acquired by the student during the coursework and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills.

6. **Project Stage – I**
Project Stage – I is the integral part of the project Work. In this, the student shall complete the partial work of the Project that will consist of problem statement, literature review, project overview, scheme of

implementation (UML/ERD/Block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. The candidate shall deliver a presentation as a part of the progress report of Project Stage – I, on the advancement in Technology pertaining to the selected dissertation topic.
The student shall submit the progress report of Research Project – I in standard format duly certified for satisfactory completion of the work by the concerned guide and head of the department/Institute.

7. **Project Stage – II**
In Project Stage – II, the student shall complete the balance part of the Project that will consist of fabrication of set up required for the project, conducting experiments and taking results, analysis & validation of results and conclusions.
The student shall prepare the final report of Project work in standard format duly certified for satisfactory completion of the work by the concerned guide and head of the department/Institute.

Note: Institute must submit the list of candidates, guide and project details (title, area, problem definition, and abstract - clearly indicating objectives and scope, sponsorship details, if any) to the university within month of commencement of Third Semester. The guide must be approved/qualified teacher of the institute. A guide can guide maximum 8 students per year.

Master of Engineering (2025 Pattern) – Mechanical (Electric Vehicle Technology)

Level 6.0

Semester I

Curriculum Structure

M.E. Mechanical – Electric Vehicle Technology – First Year (2025 Pattern)

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
PCC-501-MEV	Programme Core Course	Fundamentals of Electric Vehicles	4	-	50	50	-	-	-	100	4	-	4
PCC-502-MEV	Programme Core Course	Vehicle Dynamics for EV	4	-	50	50	-	-	-	100	4	-	4
PCC-503-MEV	Programme Core Course	Materials Science & Manufacturing for EVs	4	-	50	50	-	-	-	100	4	-	4
PCC-504-MEV	Programme Core Course	Thermodynamics & Thermal Management Systems	4	-	50	50	-	-	-	100	4	-	4
PCC-505-MEV	Laboratory-I	Simulation & Modeling Laboratory for EV	-	4	-	-	25	-	25	50	-	2	2
PEC-520-MEV	Programme Elective Course	Elective-I	3	-	50	50	-	-	-	100	3	-	3
PEC-521-MEV	Programme Elective Course	Elective-I-Fieldwork Assignment	-	2	-	-	25	-	25	50	-	1	1
		Total	**19**	**6**	**250**	**250**	**50**	**0**	**50**	**600**	**19**	**3**	**22**

Elective –I Courses:

PEC-520-MEV-A	Aerodynamics of Electric Vehicles
PEC-520-MEV-B	Crashworthiness Analysis
PEC-520-MEV-C	Modeling and Simulation of EVs
PEC-520-MEV-D	Additive Manufacturing of EV Components

Master of Engineering (2025 Pattern) – Mechanical (Electric Vehicle Technology)

Level 6.0

Semester II

Curriculum Structure

M.E. Mechanical – Electric Vehicle Technology – First Year (2025 Pattern)

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
PCC-551-MEV	Programme Core Course	Electric Motors and Drives	4	-	50	50	-	-	-	100	4	-	4
PCC-552-MEV	Programme Core Course	Battery Technology and Energy Storage Systems	4	-	50	50	-	-	-	100	4	-	4
PCC-553-MEV	Programme Core Course	Automotive HVAC	4	-	50	50	-	-	-	100	4	-	4
PCC-554-MEV	Programme Core Course	CAD and Structural Design Lab	-	4	-	-	25	-	25	50	-	2	2
PEC-571-MEV	Programme Elective Course	Elective II	3	-	50	50	-	-	-	100	3	-	3
PEC-572-MEV	Programme Elective Course	Elective III	3	-	50	50	-	-	-	100	3	-	3
SEM-580-MEV	Seminar	Seminar I	-	4	-	-	25	-	25	50	-	2	2
		Total	**18**	**8**	**250**	**250**	**50**	**0**	**50**	**600**	**18**	**4**	**22**

Elective –II Courses:

PEC-571-MEV-A	Life Cycle Analysis of EV
PEC-571-MEV-B	Automotive Testing and Certification for EV
PEC-571-MEV-C	Simulations of Transmission systems for EV
PEC-571-MEV-D	Power Electronics for EVs

Elective –III Courses:

PEC-572-MEV-A	Charging Infrastructure for EV
PEC-572-MEV-B	Artificial Intelligence in EV
PEC-572-MEV-C	Advanced CFD for Battery Thermal Management
PEC-572-MEV-D	Autonomous Vehicle Technologies

Master of Engineering (2025 Pattern) – Mechanical (Electric Vehicle Technology)

Level 6.0

Semester III

Curriculum Structure

M.E. Mechanical – Electric Vehicle Technology – Second Year (2025 Pattern)

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
RM-601-MEV	Research Methodology	Research Methodology	5	-	50	50	-	-	-	100	5	-	5
OJT-602-MEV	On Job Training/ Internship	On Job Training/ Internship	-	10	-	-	100	-	-	100	-	5	5
SEM-603-MEV	Seminar	Seminar II	-	6	-	-	25	-	25	50	-	3	3
RPR-604-MEV	Research Project	Project Stage I	-	18	-	-	25	-	25	50	-	9	9
		Total	**5**	**34**	**50**	**50**	**150**	**0**	**50**	**300**	**5**	**17**	**22**

Semester IV

Course Code	Course Type	Name of Course	Teaching Scheme		Examination Scheme						Credit		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
SEM-651-MEV	Seminar	Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-652-MEV	Research Project	Project Stage II	-	36	-	-	150	-	50	200	-	18	18
		Total	**0**	**44**	**0**	**0**	**200**	**0**	**100**	**300**	**0**	**22**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechanical (Electric Vehicle Technology)

Semester I

Semester - I

Fundamentals of Electric Vehicles [PCC-501-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><td>CCE*</td><td>End Semester Assessment</td></tr>
<tr><td>PCC-501-MEV</td><td>4</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>4</td></tr>
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1. **EV Architectures & Dynamics**
   Vehicle Topologies: Detailed study of Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), Plug-in Hybrids (PHEVs), and Fuel Cell Electric Vehicles (FCEVs); Propulsion Fundamentals: Comparative analysis between Internal Combustion Engines (ICE) and EV operating principles; Vehicle Mechanics: Modeling of tractive effort, resistance forces (aerodynamic drag, rolling resistance), and vehicle performance simulations using tools like MATLAB/Simulink.

2. **Energy Storage & Battery Management Systems (BMS)**
   Battery Technology: Electrochemical principles of Li-ion, Solid-state, and other advanced battery chemistries; Battery Pack Design: Mechanical and thermal design of battery packs, including cell-to-pack architecture and safety standards; BMS Functions: State-of-Charge (SoC) and State-of-Health (SoH) estimation, cell balancing, and protection circuits.

3. **Electric Power Trains and Drive**
   Electric Motors: Selection and sizing of motors such as BLDC, PMSM, Induction Motors (IM), and Switched Reluctance Motors (SRM); Power Electronics: Design of DC-DC converters and inverters, PWM schemes, and thermal management of power components; Transmission Systems: Single-speed vs. multi-speed gearboxes and integrated drive-axle configurations.

4. **Charging Infrastructure and Integration**
   Charging Technologies: AC Level 1/2 and DC Fast Charging, wireless charging, and battery swapping strategies; Protocols & Standards: Communication protocols (CAN-based, PLC-based) and regulatory standards like AIS-048 and ISO 26262; Smart Grid Interaction: Concepts of Vehicle-to-Grid (V2G), V2H, and the integration of renewable energy sources.

5. **Advanced Vehicle Systems & Mechanical Aspects**
   Thermal Management: Design of cooling systems for batteries and motors; Noise, Vibration, and Harshness (NVH): Analysis of unique acoustic signatures and vibration control in electric drivetrains; Safety & Diagnostics: High-voltage safety training, failure mode analysis (FMEA), and vehicle health monitoring.

References:

1. Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition by Iqbal Husain (CRC Press, 2021/2024 reprint). A systems-level approach covering technical aspects, mathematical relationships, and traction inverters.
2. Electric Vehicle Technology Explained, 2nd Edition by James Larminie and John Lowry (Wiley). Provides comprehensive coverage of energy consumption, motor design, and modelling.
3. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, 3rd Edition by Chris Mi and M. Abul Masrur (Wiley, 2026). Updated for latest industry trends like synchronous reluctance motors and cybersecurity.
4. Electric Powertrain: Energy Systems, Power Electronics and Drives by John G. Hayes and G. Abas Goodarzi (Wiley). Focuses on energy systems and drive integration for BEVs and FCEVs.
5. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 3rd Edition by Mehrdad Ehsani, Yimin Gao, and Stefano Longo (CRC Press). Widely regarded as the "bible" for fundamental theory and system-level optimization.

Semester - I

Vehicle Dynamics for EV [PCC-502-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PCC-502-MEV</td><td>4</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>4</td></tr>
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1. **Fundamentals of EV Propulsion and Resistance**
Propulsion Physics: Principles of vehicle propulsion, power-limited vs. traction-limited acceleration; External Forces: Calculation of aerodynamic drag, rolling resistance, and gradient resistance specifically for EVs; Efficiency Mapping: Energy requirements for various driving cycles (WLTP, EPA) and their impact on battery sizing.

2. **Tire and Chassis Dynamics**
Tire Mechanics: Longitudinal and lateral slip, Magic Formula tire modeling, and the impact of EV weight distribution (high-density battery packs) on tire wear and grip; Suspension Systems: Modeling of sprung and unsprung mass, damping ratios, and active/passive suspension control to manage the increased weight of EVs; Weight Distribution: Analysis of Center of Gravity (CG) and its effect on load transfer during high-torque EV acceleration.

3. **Longitudinal and Lateral Stability**
Longitudinal Dynamics: Braking performance and anti-lock braking systems (ABS) integrated with regenerative braking logic; Lateral Dynamics: Bicycle model analysis, understeer/oversteer behavior, and Electronic Stability Control (ESC); Torque Vectoring: Differential types (active, limited slip) and advanced torque distribution strategies for multi-motor AWD EV architectures.

4. **Powertrain Dynamics and Control**
Motor-to-Wheel Dynamics: Torque-speed characteristics of PMSM, Induction, and SRM motors and their interaction with transmission systems; Regenerative Braking: Energy recovery logic during deceleration and its impact on vehicle stability; Drivetrain Modeling: Simulation of power electronic converters, PWM schemes, and vector control of traction drives in a dynamic environment.

5. **Advanced Topics and Compliance**
Noise, Vibration, and Harshness (NVH): Characterization of high-frequency motor noise and condition monitoring; Autonomous Integration: Basics of ADAS (Advanced Driver Assistance Systems) and their interplay with chassis control; Regulatory Standards: Overview of functional safety (ISO 26262) and international homologation requirements.

References:

1. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach" by Amir Khajepour, M. Saber Fallah, and Avesta Goodarzi
2. Modeling, Dynamics, and Control of Electrified Vehicles" by Haiping Du, Dongpu Cao, and Hui Zhang
3. Electric Vehicles: Theory and Design" by Yiqing Yuan
4. Electric Vehicle Powertrains: Design Fundamentals, Components, and Applications" edited by B. Ashok and V. Indragandhi
5. Hybrid Electric Vehicle System Modeling and Control" (2nd Edition) by Wei Liu
6. Electric and Hybrid Vehicles: Design Fundamentals" (3rd Edition) by Iqbal Husain

Semester - I

Material Science and Manufacturing for EV [PCC-503-MEV]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-503-MEV	4	50	50	-	-	100	4

1. **Advanced Energy Materials**
   Electrochemical Storage Materials: Principles of cells and batteries, including electrochemical reactions and factors affecting battery performance; Battery Chemistries: Fundamentals and materials for Lead-acid, Nickel-based, and Lithium-ion batteries; exploration of next-generation batteries like solid-state and flow batteries; Electrode Synthesis: Processes for material synthesis, electrode preparation, and cell assembly for Li-ion and advanced chemistries; Hydrogen & Fuel Cells: Production, storage, and application of hydrogen in solid-state and liquid materials for fuel cell vehicles.

2. **Structural Materials & Lightweighting**
   Alloys and Composites: Use of lightweight structural alloys (aluminum, magnesium), superalloys, and carbon-fiber-reinforced polymers for vehicle bodies; Functional Materials: Shape memory alloys, nanomaterials, and engineering ceramics for specialized EV components; Characterization Techniques: Microscopy (AFM, SEM), spectroscopy, and X-ray diffraction (XRD) for material analysis and failure diagnosis.

3. **EV Manufacturing Processes**
   Battery Pack Manufacturing: Cell-to-pack assembly, battery architecture, and passive component sizing; Advanced Fabrication: Introduction to Additive Manufacturing (3D printing), semi-solid processing, and thin-film coatings for EV parts; Precision Machining: Micromachining and surface engineering techniques for high-performance drivetrain components; Vehicle Body Production: Evaluation of modern methods for vehicle body manufacturing and chassis dynamometer testing.

4. **Component-Specific Manufacturing & Testing**
   Electric Motor Production: Manufacturing of traction motors (BLDC, PMSM, SRM) and motor characterization (power and efficiency) as per international standards like AIS 041 and ECE R85; Thermal Management Systems: Manufacturing and design of heat exchangers, thermal interface materials, and cooling systems for batteries and motors; Integration & Standards: Regulatory requirements for EV manufacturing (e.g., AIS-048, ECE R100) and environmental durability testing.

5. **Sustainability & Lifecycle**

Battery Recycling: Material recovery processes and "energy-as-a-service" business models; Reliability Engineering: Failure analysis techniques including FMEA (Failure Mode and Effects Analysis), ISO 26262, and fault tree analysis; Environmental Impact: Assessment of materials and manufacturing processes for carbon management and net-zero strategies

References:

1. Lightweight Materials for Electric Vehicles: Sustainable Materials, Production Process, and Modeling Techniques, Edited by R. Suresh, C. Durga Prasad, Satish Kumar, K.N. Bharath, Ajith G. Joshi
2. Materials, Design and Manufacturing for Lightweight Vehicles Edited by P. K. Mallick, 2nd Ed, 2020
3. Modern Battery Engineering: A Comprehensive Introduction by Kai Peter Birke, 2026 reprint
4. Complete Technology Book on Electric Vehicles Manufacturing, EIRI Board, 2026

Semester - I

Thermodynamics & Thermal Management Systems for EV [PCC-504-MEV]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Paper					
	Lect. /Week	CCE*	End Semester Assessment	TW	Oral/ Presentation	Total	
PCC-504-MEV	4	50	50	-	-	100	4

1. **Advanced Thermodynamics for EVs**
   Application of First and Second Laws to energy storage and conversion systems; Thermodynamic cycles including refrigeration and heat pump cycles for cabin HVAC and battery cooling; Energy and exergy analysis of EV powertrain components.

2. **Battery Thermal Management Systems (BTMS)**
   Heat generation mechanisms during charge and discharge cycles; Active and passive cooling/heating methods (air-cooled, liquid-cooled, and phase-change materials); Safety protocols for managing thermal runaway and heat propagation.

3. **Thermal Management of Power Electronics & Motors**
   Cooling of traction motors (PMSM, IM) and power electronic converters; Design of heat sinks, metal foams, and liquid-cooled cold plates; Integration of micro-channel heat exchangers and jet impingement techniques.

4. **Integrated Vehicle Thermal Management (IVTM)**
   Holistic strategies for balancing cabin comfort (HVAC) with component cooling; Real-time thermal monitoring using sensors and control algorithms; System-level simulation and modeling using 1D and 3D computational tools.

5. **AI-Driven Thermal Management**
   Predictive Thermal Control: Using Machine Learning (ML) and Artificial Neural Networks (ANN) to predict junction temperatures and thermal health based on real-time sensor data and driving patterns; Fault Detection & Diagnostics: AI models for identifying early signs of thermal runaway, cooling system leaks, or sensor failures to enhance vehicle safety; Fast-Charging Optimization: AI-based strategies that dynamically adjust thermal regulation to allow 80% charging within 30 minutes without degrading battery health

References:

1. Thermal Battery Management System for Hybrid and Electric Vehicles Hardcover – 23 September 2025 by Ashwani Kumar, Mukesh Kumar Awasthi, Nitesh Dutt, Yogesh Kumar Singla, Sivasakthivel Thangavel; Wiley Publications
2. Thermal Management for Batteries: From Basic Design to Advanced Simulation and Management Methods (1st Edition, 2024) edited by Hafiz Muhammad Ali
3. Thermal Energy Management in Vehicles (Automotive Series) by Vincet Lemort, Gerard Olivier, Georges de Pelsemaeker, JOHN WILEY NP (ORIGINAL); 1st edition (9 March 2023); JOHN WILEY
4. Handbook of Thermal Management Systems: e-Mobility and Other Energy Applications Paperback – Import, 24 August 2023 by Fethi Aloui, Edwin Geo Varuvel, Ankit Sonthalia

Semester - I

Simulation and Modelling Laboratory for EV [PCC-505-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PCC-505-MEV</td><td>4</td><td>-</td><td>-</td><td>25</td><td>25</td><td>50</td><td>2</td></tr>
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Simulation and Modelling Laboratory for EV file shall consist of the following assignments/experiments

1. Vehicle modeling using MATLAB/Simulink or Ansys for powertrain and battery performance.
2. Performance testing on Chassis Dynamometers and durability tests in environmental chambers.
3. Battery discharge characterization through modelling of a Lithium-Ion battery pack to observe voltage and current under constant and variable loads
4. Design of a model to simulate passive or active cell balancing
5. Testing and validation of battery packs, experimental heat transfer analysis, and sensor calibration
6. System-level simulation and modeling using 1D and 3D computational tools.
7. Demonstration of thermal modeling and simulation using Ansys Fluent, MATLAB/Simulink, and GT-Suite.
8. Simulate common faults (e.g., motor sensor failure or battery over-temperature) and design safety response logic.

Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus. Laboratory work it is to be submitted as term work at the end of the semester after continuous assessment of each by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester - I

Elective-I
Aerodynamics of Electric Vehicle [PEC-520-MEV-A]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-520-MEV-A	3	50	50	-	-	100	3

1. **Fundamentals of Automotive Aerodynamics**
   Introduction to Fluid Mechanics: Conservation of mass, momentum, and energy equations in the context of vehicle flow. Aerodynamic Forces: Detailed analysis of drag, lift, and side forces; pitching, rolling, and yawing moments. EV-Specific Aerodynamics: Comparison between Internal Combustion Engine (ICE) and EV aerodynamic requirements; the "range-to-drag" sensitivity. Flow Regimes: Laminar and turbulent boundary layers, flow separation, and vortex formation.

2. **External Aerodynamics & Drag Reduction**
   Body Shape Optimization: Impact of vehicle silhouettes (hatchback, sedan, SUV) on the drag coefficient ((C_d); Frontal Area and Underbody: Design of smooth under-trays for EVs (facilitated by flat battery packs) and active grill shutters for variable cooling; Wheel and Tire Aerodynamics: Aerodynamic wheel covers, air curtains, and the impact of tire width on turbulence; Add-on Devices: Use of spoilers, diffusers, and vortex generators to delay separation.

3. **Thermal Management & Internal Flows**
   Cooling System Aerodynamics: Drag penalties from cooling air intakes, air ducting for battery packs, traction motors, and power electronics; Heat Exchange Performance: Optimizing the location of radiators and heat pumps in EVs; HVAC Integration: Impact of cabin ventilation and AC performance on overall vehicle energy consumption and range.

4. **Computational Fluid Dynamics (CFD) for EVs**
   Numerical Modeling: Introduction to finite volume methods and RANS (Reynolds-Averaged Navier-Stokes) equations; Meshing Techniques: Advanced meshing for complex EV geometries including the motor and battery cooling circuits; Simulation Software: Hands-on training with industry-standard tools like Ansys Fluent, Open FOAM, or Star CCM+ for external flow and thermal simulations.

5. **Experimental Techniques and Validation**
   Wind Tunnel Testing: Full-scale and model-scale testing; moving ground plane simulations to account for wheel rotation; Measurement Instrumentation: Pitot tubes, hot-wire anemometry, and Pressure

Sensitive Paint (PSP); Flow Visualization: Use of smoke, dye, and PIV (Particle Image Velocimetry) for identifying wake structures; Real-World Correlation: Validating CFD and wind tunnel data with on-road coast-down tests.

References:

1. Fundamentals of Aerodynamics by John D. Anderson;
2. Aerodynamics of Road Vehicles by Wolf-Heinrich Hucho. Industry
3. Tools: Proficient use of MATLAB/Simulink for aerodynamic force modeling and Ansys for 3D simulations.
4. Aerodynamics of Road Vehicles by Thomas Schuetz, published by SAE international

Semester - I

Elective-I
Crashworthiness Analysis [PEC-520-MEV-B]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-520-MEV-B	3	50	50	-	-	100	3

1. **Fundamentals of Crashworthiness & Safety Standards**
Concepts: Definition of crashworthiness, energy absorption, and occupant protection; Crash Modes: Frontal, side-impact (pole and barrier), rear-impact, and rollover scenarios; Regulations: Introduction to FMVSS (Federal Motor Vehicle Safety Standards), Euro NCAP, and AIS standards specific to EVs; Metrics: Head Injury Criterion (HIC), chest deformation, and intrusion limits.

2. **EV-Specific Crashworthiness Challenges**
Mass & Packaging: Impact of heavy battery packs on vehicle kinetic energy and center of gravity; Battery Protection: Design of protective frames (sills) and enclosures to prevent intrusion and mechanical abuse; Post-Crash Safety: Managing high-voltage isolation, fire safety, and thermal runaway prevention after impact; Comparison: Key differences in structural load paths between ICE and EV platforms.

3. **Structural Mechanics & Energy Absorption**
Crumple Zones: Design of front and rear structures for progressive collapse and energy dissipation; Thin-Walled Structures: Axial and lateral crushing of tubes; use of high-strength steels and aluminum alloys; Advanced Materials: Introduction to composite materials (CFRP) and bio-inspired honeycomb structures for EV lightweighting and energy absorption.

4. **Finite Element Analysis (FEA) for Crash Simulation**
Mathematical Basis: Difference between implicit and explicit FEA; governing equations of motion for high-speed dynamic events; Preprocessing: Mesh generation for Body-in-White (BIW) using tools like Hyper Mesh or ANSA; 2D shell vs. 3D solid meshing; Model Setup: Defining boundary conditions, initial velocities, and contact interfaces (e.g., CONTACT_AUTOMATIC_SURFACE_TO_SURFACE)

5. **Computational Modeling & Solver Techniques**
Material Modeling: Strain-rate dependency, piecewise linear plasticity, and failure criteria for crash scenarios; Solver Operations: In-depth study of LS-DYNA or RADIOSS; keywords, time-step control, and hourglass energy management; Specialized Models: Modeling airbags, seatbelts, and Hybrid III dummies for injury estimation.

References:

1. Electric and Hybrid Vehicles: Design Fundamentals (3rd Edition, 2024/2025) by Iqbal Husain
2. Electric and Hybrid Vehicles by Tom Denton and Hayley Pells
3. Vehicle Technology: Technical Foundations of Current and Future Motor Vehicles by De Gruyter
4. Crashworthiness: Energy Management and Occupant Protection by Jorge AC Ambroiso
5. Automotive Accident Reconstruction: Practices and Principles 2nd Edition by Donald E. Struble
6. LS-DYNA Theory Manual by Livermore Software Technology Corporation (LSTC)

Semester - I

Elective-I
Modeling and Simulation of [PEC-520-MEV-C]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PCC-520-MEV -C</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
</table>

1. **Vehicle Dynamics and Propulsion Modeling**
   Longitudinal Dynamics: Modeling of tractive effort, rolling resistance, aerodynamic drag, and hill-climbing forces; Performance Parameter Modeling: Simulation of acceleration performance and range for electric scooters, small cars, and heavy-duty EVs; Standard Drive Cycles: Implementing EPA, WLTP, and custom drive cycles for range estimation and energy consumption analysis; Lateral Dynamics: Basic steering and stability models for handling simulation.

2. **Energy Storage Systems and Battery Modeling**
   Battery Architectures: Equivalent-circuit models (ECM), physics-based models (PBM), and data-driven empirical modeling; Cell to Pack Modeling: Simulation of battery modules, cell aging, and state-of-charge (SOC) estimation techniques; Battery Management Systems (BMS): Modeling of passive and active cell balancing, fault detection, and thermal influence on battery life.

3. **Electric Drivetrain and Motor Control**
   Motor Characterization: Modeling and simulation of BLDC, PMSM, and Induction motors for traction; Control Strategies: Implementation of Field-Oriented Control (FOC), Direct Torque Control (DTC), and speed-voltage-current integration via MCU models; Transmission Modeling: Modeling of multi-mode electrically variable transmissions and gear-ratio optimization for efficiency.
4. **Power Electronics and Energy Management**
   Converter Simulations: Modeling DC-DC and AC-DC bidirectional converters in open and closed loops; Energy Management Systems (EMS): Simulation of multi-source energy optimization involving batteries, ultracapacitors, and fuel cells; Regenerative Braking: Modeling energy recovery strategies and their impact on vehicle deceleration.

5. **Thermal Management and CFD**
   Battery Thermal Management (BTMS): Computational Fluid Dynamics (CFD) analysis for air-cooled and liquid-cooled battery packs; External Aerodynamics: Simulation of drag reduction to optimize vehicle range and design efficiency; Component Cooling: Heat transfer modeling for electric motors and power electronic PCBs.
   References:

1. Modeling and Simulation for Electric Vehicle Applications by Amine Fakhfakh, Mohamed, Intech Open
2. Electric Vehicle Design: Design, Simulation, and Applications by Himanshu Sharma, Krishan Arora, Suman Lata Tripathi, John Wiley & Sons

Semester - I

Elective-I
Additive Manufacturing of EV Components [PEC-520-MEV-D]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PCC-520-MEV-D</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
</table>

1. **Fundamentals of Additive Manufacturing and EV Technology**
   Introduction to Additive Manufacturing: Overview of AM, distinction from conventional manufacturing, the generic AM process chain (CAD, STL conversion, machine setup, build, post-processing), advantages, and limitations; AM Processes Classification: Detailed study of the seven AM categories: Vat Photopolymerization (SLA, DLP), Material Extrusion (FDM/FFF), Powder Bed Fusion (SLS, SLM, EBM), Material Jetting, Binder Jetting, Sheet Lamination, and Directed Energy Deposition (DED); Electric Vehicle Fundamentals: Overview of EV components (motors, batteries, power electronics, chassis, cooling systems), drivetrain topologies, and key performance metrics (e.g., lightweighting, thermal management, power density).

2. **Design for Additive Manufacturing (DFAM) for EVs**
   DFAM Principles: Design rules and guidelines for AM, leveraging design freedom (complex geometries, internal channels, lattice structures) not possible with traditional methods; Computational Design Tools: Use of CAD software for AM, data handling and standardization (STL, 3MF, AMF formats), topology optimization, generative design, and simulation tools; Part Orientation and Support Generation: Strategies for optimal build orientation, support structure design and removal, and minimizing defects (e.g., residual stress, warping).

3. **Materials for EV Additive Manufacturing**
   Polymer and Composite Materials: Properties, processing, and applications in EVs (e.g., reinforced polymers for housing, interior components, jigs, and fixtures); Metal Alloys and Ceramics: Focus on metal powders (e.g., AlSi10Mg, copper, tool steel) used in AM for structural and functional components; Material Characterization: Techniques for analyzing microstructure, mechanical behavior, and thermal properties of additively manufactured components; Multi-Material and Functionally Graded Materials: Exploration of using multiple materials for functional integration in a single build.

4. **AM Applications in EV Components**

Powertrain Components: Case studies on additively manufactured motor housings, rotors with lattice structures for weight reduction, and optimized windings for increased power density; Thermal Management Systems: Design and manufacturing of integrated cooling channels for batteries, power electronics, and motors to improve efficiency and heat dissipation; Chassis and Structural Components: Application of AM for lightweight brackets, connectors, and customized structural parts; Prototyping and Tooling: Role of AM in rapid prototyping for accelerated EV development cycles and production of custom tooling and molds.

5. **AM Process Optimization, Quality Control, and Post-Processing**

Process Parameter Optimization: Critical parameters (geometry, temperature, composition) and their effect on part quality and performance; Post-Processing Techniques: Support removal, surface finishing, heat treatments (e.g., hot isostatic pressing, stress relief), and property enhancement methods; Quality Assurance: Defect analysis in AM parts, non-destructive testing, and standardization in the AM industry; Process Modeling: Introduction to mathematical modeling of AM processes, including heat transfer and fluid flow simulation.

References:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing by Gibson, Rosen, and Stucker.
2. Rapid Manufacturing: An Industrial Revolution for the Digital Age by Hopkinson, Hague, and Dickens.
3. A Practical Guide to Design for Additive Manufacturing (Springer, 2019)
4. 3D Printed Conducting Polymers: Fundamentals, Advances and Challenges (CRC Press, 2024)
5. Practical Implementations of Additive Manufacturing Technologies edited by Shashanka Rajendrachari (Springer Nature Singapore, 2023).

Semester I

Elective-I
Field Work Assignment for Aerodynamics of Electric Vehicles
[PEC-521-MEV-A]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
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<tr><td>PCC-521-MEV-A</td><td>2</td><td>-</td><td>-</td><td>25</td><td>25</td><td>50</td><td>1</td></tr>
</table>

The Aerodynamics of Electric Vehicles field work file shall consist of the following assignments

1. Benchmarking the drag coefficient (C_d) across current commercial EV models
2. Inspecting flat-floor designs and diffuser efficiency on diverse EV chassis.
3. Analyzing the integration of air intakes with liquid cooling heat exchangers
4. Acoustic testing and noise, vibration, and harshness (NVH) data collection
5. Site visits to R&D centers using high-performance computing (HPC) for flow visualization.

The filed work is to be submitted as term work at the end of semester after continuous assessment by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester I

Elective-I
Field Work Assignment for Crashworthiness Analysis
[PEC-521-MEV-B]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-521-MEV-B	2	-	-	25	25	50	1

The Crashworthiness Analysis field work file shall consist of the following assignments

1. To conduct physical teardowns of decommissioned 2024-2025 EV and ICE vehicle frames to identify structural reinforcements in EV "skateboards" versus traditional chassis.
2. Field observation of mechanical crush and nail penetration tests on non-functional "dummy" battery cells to study energy absorption and enclosure integrity.
3. Visit to an authorized testing center (e.g., ARAI, ICAT, or Global NCAP partners) to observe a 2026-standard frontal offset or side pole impact test.
4. To analyze the deployment timing of 2026-mandatory 6-airbag systems and the effectiveness of pyrotechnic seat belt pretensioners
5. To develop a virtual crash model of a 2026-spec light electric vehicle (LEV) using LS-DYNA or Radioss, analyzing deceleration curves and intrusion measurements.

The filed work is to be submitted as term work at the end of semester after continuous assessment by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester I

Elective-I

Field Work Assignment for Modeling and Simulation of EVs [PEC-521-MEV-C]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
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<tr><td>PCC-521-MEV-C</td><td>2</td><td>-</td><td>-</td><td>25</td><td>25</td><td>50</td><td>1</td></tr>
</table>

The Modeling and Simulation of EVs is field work file shall consist of the following assignments

1. Benchmarking real-world driving data; implementing standard drive cycles (e.g., FTP75, ECE, WLTP) to determine tractive effort and energy demand.
2. Simulation of battery thermal management systems (BTMS); modeling cell balancing and high-voltage safety protocols.
3. Simulation of power electronic converters (DC-DC and DC-AC) and their efficiency mapping.
4. Modeling regenerative braking efficiency; impact of energy recovery on battery thermal and cycle life.
5. Simulation of frontal and side-impact crash tests; analyzing the impact of battery weight on vehicle center of gravity (CG).

The filed work is to be submitted as term work at the end of semester after continuous assessment by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester I

Elective-I

Field Work Assignment for Additive Manufacturing of EV Components [PEC-521-MEV-D]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><td>CCE*</td><td>End Semester Assessment</td></tr>
<tr><td>PCC-521-MEV-D</td><td>2</td><td>-</td><td>-</td><td>25</td><td>25</td><td>50</td><td>1</td></tr>
</table>

The Additive Manufacturing of EV Components is field work file shall consist of the following assignments

1. Select a conventional metal motor bracket and create its digital twin for AM optimization.
2. To redesign a battery pack housing to include optimized lattice structures for impact protection
3. Conduct a feasibility study on using printed copper for a specific EV motor coil design.
4. To print a functional prototype of a multifunctional power electronics housing.
5. To test a 3D-printed component for dimensional accuracy and surface roughness against industrial tolerances.

The filed work is to be submitted as term work at the end of semester after continuous assessment by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechanical (Electric Vehicle Technology)

Semester II

Semester-II

Electric Motors and Drives [PCC-551-MEV]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-551-MEV	4	50	50	-	-	100	4

1. **Introduction to Electric Vehicles and Drive Principles**
EV Architectures: Classification and components of Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), and Plug-in Hybrid Electric Vehicles (PHEVs); Vehicle Dynamics: Modeling and simulation of vehicle motion, including tractive effort, acceleration force, braking, and aerodynamic drag; Drive Train Topology; Analysis of different electric drive train configurations (series, parallel, series-parallel); Motor Requirements: Key specifications and performance criteria for motors in EV applications (power density, efficiency, torque characteristics).

2. **Electric Motors for EVs**
Motor Principles Review: Fundamentals of magnetic circuits, DC and AC machines, voltage, and torque equations; Types of EV Motors: Construction, working principles, and characteristic curves of key motor types: DC Motors, Induction Motors (IM),Permanent Magnet Synchronous Motors (PMSM), Brushless DC (BLDC) Motors, Switched Reluctance Motors (SRM); Efficiency Maps: Understanding and interpreting motor efficiency under various speed and torque conditions; Motor Design Variables: Introduction to material properties (e.g., PM materials) and design considerations for EV motors.

3. **Power Electronics and Converters**
Power Semiconductor Devices: Working and characteristics of power diodes, MOSFETs, and IGBTs; Power Converters: Operation of key power electronic circuits in EVs: Uncontrolled and controlled rectifiers (single and three-phase) DC-DC choppers (four-quadrant operation) DC-AC Inverters (single and three-phase); PWM Techniques: Pulse Width Modulation for inverter control and realization of power electronic converters.

4. **Control of Electric Motor Drives**
Drive Characteristics: Speed control for constant torque and constant power operations; Control Strategies: V/f control for induction motors, Vector Control (Field-Oriented Control) for PMSM and IM drives (sensored and sensor-less), Modeling of motors in stationary and rotating reference frames (RFO frame), Control of BLDC and SRM drives; Regenerative Braking: Principles and control techniques for energy recovery during braking; Modeling and Simulation: Use of software tools like MATLAB/Simulink for system modeling and performance analysis.

5. **Advanced Topics and Integration**
Motor Load Dynamics: Matching motor and load characteristics for optimal performance; Thermal Management: Modes of heat transfer and cooling techniques for motors and drives; Safety and Standards: High-voltage safety protocols and relevant global standards (e.g., ISO 26262) for motor systems; Case Studies: Analysis of motors and drives used in current high-end commercial EVs.

References:

1. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes and G. Abas Goodarzi. Wiley.
2. Electric Vehicle Machines and Drives: Design, Analysis and Application, K. T. Chau. Wiley (Wiley-IEEE Press imprint).
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Stefano Longo, and Kambiz Ebrahimi, CRC Press.
4. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Husain. CRC Press.
5. Electric Motors and Drives: Fundamentals, Types, and Applications, Austin Hughes and Bill Drury. Elsevier (Newness imprint).
6. Handbook of Automotive Power Electronics and Motor Drives, CRC Press.
7. Electric Motor Drives: Modeling, Analysis, and Control, R. Krishnan. Prentice Hall / Pearson.
8. Analysis of Electric Machinery and Drive Systems, Paul C. Krause, Oleg Wasynczuk, and Scott D. Sudhoff. IEEE Press/Wiley.
9. Electric Vehicle Technology, James Larminie and John Lowry, Wiley
10. Power Electronics: Converters, Applications, and Design by Ned Mohan, Tore M. Undeland, and William P. Robbins, John Wiley & Sons.
11. Electric Drives and Electromechanical Systems: Applications and Control, Richard Crowder

Semester-II

Battery Technology and Energy Storage Systems [PCC-552-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PCC-552-MEV</td><td>4</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>4</td></tr>
</table>

1. **Fundamentals of Electrochemistry and Battery Principles**
Introduction to Energy Storage: Role and significance of energy storage in electric vehicles and grid integration; Electrochemical Principles: Principles of operation of cells and batteries, electrochemical reactions, and energy conversion processes; Battery Terminology and Characteristics: Key parameters such as capacity (Ah), voltage, C-rate, depth of discharge (DOD), state of charge (SOC), state of health (SOH), impedance, and life cycles; Battery Classification: Primary and secondary batteries, different types including lead-acid, Ni-based, and various lithium-ion (Li-ion) chemistries (LCO, NCA, NMC, LFP, etc.).

2. **Battery Technology for Electric Vehicles**
Cell Chemistries and Materials: Detailed study of materials used in EV batteries, electrode preparation, and cell assembly processes; Performance Criteria: Specific performance requirements for EV batteries (power density, energy density, efficiency, safety) and factors affecting performance; Next-Generation Batteries: Overview of advanced and emerging technologies like solid-state batteries, flow batteries, and sodium-ion batteries; Other Storage Systems: Introduction to alternative energy storage such as super capacitors and fuel cells, and hybridization of energy storage systems.

3. **Battery Modeling and Simulation**
Modeling Approaches: Equivalent Circuit Models (ECMs), physics-based models (PBMs), and data-driven/empirical modeling; Mathematical Modeling: Developing and implementing mathematical models for battery cells and packs using simulation tools like MATLAB/Simulink; Vehicle Range Estimation: Calculating energy consumption based on driving cycles and estimating vehicle range; Cell Characterization: Laboratory methods and techniques for testing and characterizing battery cells (charge/discharge cycles, EIS, CV).

4. **Battery Pack Design and Management Systems (BMS)**
Battery Pack Architecture: Design considerations for modules and complete packs, including electrical connections (series/parallel configurations) and mechanical enclosure design; Battery Management System (BMS): Need, functionality, and topologies (centralized, modular, distributed); BMS Features: Sensing - Voltage, current, and temperature measurement.State Estimation - Advanced methods for SOC and SOH estimation (e.g., Kalman Filters and their variations); Cell Balancing: Passive and active Techniques to ensure uniform cell performance and longevity ; Protection: High-voltage safety protocols, fault detection, diagnostics, and overcharge/over-discharge protection; Communication: CAN and RS485 communication protocols.

5. **Thermal Management and Safety**
Thermal Management Systems (TMS): Need for TMS in batteries to prevent thermal runaway; modes of heat transfer in battery packs; Cooling Techniques: Design and analysis of air, liquid, direct refrigerant, and phase-change material (PCM), cooling systems; Simulation: Using Computational Fluid Dynamics (CFD) tools like ANSYS Fluent or OpenFOAM for thermal modeling and heat dissipation analysis; Safety and Standards: High-voltage safety handling, crashworthiness, and adherence to global standards and regulations (e.g., ISO 26262, AIS standards).

References

1. Battery Management Systems, Volume II: Equivalent-Circuit Methods, Gregory Plett,
2. A Systems Approach to Lithium-Ion Battery Management (Power Engineering), Artech Phil Weicker,
3. Battery Modeling Volume I: Battery Modeling (Power Engineering), Artech Gregory L Plett,
4. Handbook on Battery Energy Storage System, Asian Development Bank.
5. Advanced Battery Management Technologies for Electric Vehicles, Xiong & Shen.
6. Vehicular Electric Power Systems, Ali Emadi
7. Battery Systems Engineering, Christopher D. Rahn and Chao-Yang Wang.
8. The Handbook of Lithium-Ion Battery Pack Design: Chemistry, Components, Types and Terminology, John Warner.
9. Thermal Battery Management System for Hybrid and Electric Vehicles (Edited, 2025) by Ashwani Kumar, Mukesh Kumar Awasthi, Nitesh Dutt, Yogesh Kumar Singla, Sivasakthivel Thangavel, and others.
10. Battery Management System, Venu Sangwan.
11. Battery Management in Electric Vehicles—Current Status and Future Trends, Prodip K. Das.
12. Electric Vehicle Battery Management, Sandeep Dhameja.
13. V. Sangwan, R. Kumar and A. K. Rathore, "Estimation of model parameters and state-of-charge for battery management system of Li-ion battery in EVs," 2017 IEEE Transportation Electrification Conference (ITEC-India), Pune, India, 2017, pp. 1-6, doi: 10.1109/ITEC-India.2017.8333889.

Semester-II

Automotive HVAC [PCC-553-MEV]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PCC-553-MEV	4	50	50	-	-	100	4

1. **Fundamentals of Thermodynamics and Heat Transfer in Automotive Applications**
   Principles of Heat Transfer: In-depth study of conduction, convection, and radiation, and how these modes apply to heat exchange within vehicle systems; Thermodynamics and Refrigeration Cycles: Review of thermodynamic laws and detailed analysis of the vapor-compression refrigeration cycle, focusing on efficiency (COP); Automotive HVAC Basics: Purpose and importance of HVAC in vehicles, including basic components (compressor, condenser, evaporator, expansion valve, heater core, blower motors); Psychrometry: Understanding air properties and humidity control in the cabin for passenger comfort.

2. **EV Thermal Dynamics and Heat Generation**
   Heat Sources in EVs: Identification and quantification of heat generation from key EV components; Batteries: Heat generation models (Bernardi model), thermal characteristics of Li-ion cells, and thermal runaway phenomena and prevention; Power Electronics: Heat dissipation in inverters, DC-DC converters, and on-board chargers; Traction Motors: Iron, winding, and mechanical losses leading to heat generation; Thermal Balance of the Vehicle: Analyzing the overall energy balance and heat flow within the EV architecture, considering ambient temperature and driving conditions.

3. **EV-Specific Heating and Cooling Technologies**
   Cabin Heating Innovations: Challenges in heating the cabin in winter without an IC engine; comparison of technologies; Positive Temperature Coefficient (PTC) Heaters: Architecture, operation, and high energy consumption impact on range; Heat Pump Systems: Principles of operation (cooling in summer, heating in winter), system architecture, efficiency improvement (COP), and defrosting strategies; Waste Heat Recovery: Utilizing waste heat from motors and power electronics to assist in cabin or battery heating; Cooling Strategies for High Voltage Components: Air Cooling vs. Liquid Cooling: Comparison of effectiveness, complexity, and application; Refrigerant-based Cooling: Direct expansion (DX) systems for batteries and cabin; Advanced Materials: Application of Phase Change Materials (PCMs), immersion cooling.

4. **System Design, Control, and Simulation**
   Integrated Thermal Management Systems (ITMS): Design and analysis of complex, coupled thermal loops (that manage battery, motor, power electronics, and cabin thermal requirements simultaneously); Modeling and Simulation: Use of simulation software (e.g., MATLAB/Simulink, CFD tools) for heat dissipation analysis, performance prediction, and optimization of thermal designs; Control Strategies: Development of intelligent thermal control algorithms to optimize efficiency, enhance battery performance, and ensure safety across various operating conditions; Components Sizing: Methods for calculating thermal loads and sizing components like compressors, chillers, pumps, fans, and heat

exchangers; Sensors and Actuators: Integration of temperature and pressure sensors, valves, and actuators for real-time monitoring and control.

5. **Safety, Environmental, and Future Trends**
Safety Considerations: High-voltage safety protocols, thermal runaway prevention, and fire safety in thermal systems; Refrigerants and Regulations: Environmental impact of refrigerants, global regulations (e.g., phasing out HFCs), and the use of eco-friendly alternatives; Future Innovations: Exploration of emerging technologies such as thermoelectric cooling, advanced heat pipe integration, and AI-driven HVAC optimization.

References:

1. HVAC Systems in Electric Vehicles: Design, Efficiency, and Future Innovations Kindle Edition, Charles Nehme
2. *HVAC Systems in Electric Vehicles* and *Thermal Energy Management in Vehicles*, Charles Nehme
3. Automotive Air Conditioning and Climate Control Systems, Steven Daly.
4. Thermal Energy Management in Vehicles, Vincent Lemort, Gerard Olivier, Georges de Pelsemaeker
5. Refrigeration and Air Conditioning, Manohar Prasad, New Age International.
6. Refrigeration and Air Conditioning, C.P. Arora, McGraw Hill.
7. A Course in Refrigeration and Air Conditioning, Arora & Domkundwar, Dhanpat Rai & Co.
8. Daly, Steven. Automotive air conditioning and climate control systems. Elsevier.
9. M. A. Al Faruque and K. Vatanparvar, "Modeling, analysis, and optimization of Electric Vehicle HVAC systems," 2016 21st Asia and South Pacific Design Automation Conference (ASP-DAC), Macao, China, 2016, pp. 423-428, doi: 10.1109/ASPDAC.2016.7428048.

Semester-II

CAD and Structural Design Lab [PCC-554-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
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<tr><td>PCC-554-MEV</td><td>4</td><td>-</td><td>-</td><td>25</td><td>25</td><td>50</td><td>2</td></tr>
</table>

CAD and Structural Design Lab file shall consist of the following assignments / experiments

1. Model simple components like a motor bracket or suspension link.
2. Create a detailed 3D model of a standard EV traction motor casing and perform static structural analysis (FEA) on its mounting points.
3. Model the transmission housing and conduct stress analysis.
4. CAD model of a disc brake assembly and basic thermal analysis (CFD introduction).
5. Design a standard battery module housing using CAD software.
6. Simulate a battery thermal management system using CFD analysis to analyze heat dissipation within the pack.
7. Conduct drop tests or impact simulations (FEA dynamic analysis introduction) on the battery pack design.
8. Model a simplified EV chassis or frame structure in CAD.
9. Create an assembly model integrating the battery pack, motor, suspension, and body onto the chassis.
10. Perform simplified frontal or side-impact simulations (FEA/CAE) on critical structural components or the overall chassis.
11. Prepare comprehensive design reports, including CAD models, simulation results, engineering drawings (with tolerancing), and material specifications.

Laboratory work or Assignments have to be carried out at respective labs as mentioned in the syllabus. Laboratory work is to be submitted as term work at the end of the semester after continuous assessment of each by respective teacher. Assessment of term work has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

Semester-II

Elective II Life Cycle Analysis of EV [PEC-571-MEV-A]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>PEC-571-MEV-A</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
</table>

1. Fundamentals of Life Cycle Assessment (LCA)
Introduction to LCA: Definition, purpose, and historical context; ISO Standards: Overview of ISO 14040 and ISO 14044 guidelines for conducting LCAs; Four Phases of LCA: Goal and Scope Definition, Life Cycle Inventory (LCI), Life Cycle Impact Assessment (LCIA), and Interpretation;
Functional Unit and System Boundaries: Defining the basis for comparison (e.g., "passenger-km traveled") and setting the scope (cradle-to-grave, cradle-to-gate).

2. Raw Material Extraction and Processing (Cradle)
Material Requirements for EVs: Focus on critical minerals (lithium, cobalt, nickel, rare earth elements) for batteries and motors; Extraction Impacts: Environmental burdens and social/ethical considerations of mining and processing these materials; Energy Consumption: Energy inputs required for material synthesis and electrode paste production; Comparison with Internal Combustion Engine Vehicles (ICEV) Materials: Assessing the material differences in conventional vehicle supply chains.

3. Manufacturing and Assembly Phase
Vehicle Production: Energy consumed and emissions generated during the assembly of the vehicle chassis, body, and components; Battery Manufacturing: Detailed analysis of cell and battery pack assembly processes, which are major contributors to the production phase impact;
Powertrain & Battery Manufacturing (Distinct from ICEV), Battery Cell Production: Anode/cathode/separator assembly, electrolyte filling, and sealing.; Battery Module Assembly: Cells are precisely stacked, framed (steel/aluminum), and bonded (gluing, riveting) for stability;
Battery Pack Assembly: Modules are integrated into a tray with thermal management (gap fillers), cooling loops, BMS, and electrical components (HV cables); Motor Manufacturing: Involves rotor/stator assembly, coil winding, and magnet fitment, with rigorous testing; Final Assembly
Chassis/Drivetrain Integration: Installation of the battery pack, electric motor, and power electronics; Interior/Exterior: Installation of dashboard, infotainment, seats, lights, and other trim.
Software & Testing: Firmware flashing and extensive electrical/safety testing of high-voltage systems.

4. Use Phase and Operation
Energy Consumption: Electricity consumption of the EV during operation (Wh/km); Grid Mix Impact: Analyzing emissions based on the regional electricity sources (e.g., coal-intensive vs. renewable-heavy grids); Maintenance and Repair: Environmental impacts of spare parts, lubricants (if any), and service

activities; Lifetime Analysis**:** Factors affecting vehicle life and battery cycle life, including charging/discharging characteristics and performance testing.

5. End-of-Life (EoL) Management

Disposal Processes: Land filling and waste treatment impacts; Battery Second-Life Applications: Opportunities for reusing EV batteries in stationary energy storage systems; Recycling and Recovery: Technologies and challenges for recovering critical metals and materials from spent batteries and vehicles; Circular Economy Principles: Strategies for material recovery to minimize virgin material use and resource depletion; Sustainability: Battery recycling processes, lifecycle analysis, and environmental impact.

References:

1. Environmental Impacts of Electric Vehicles" Dr. Mukesh Pandey
2. Thermal Management of Electric Vehicle Battery Systems, Ibrahim Dincer et al.
3. Life Cycle Assessment (LCA) 102: Electric Vehicle (EV) Global Warming Benefits
4. Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products (Curran, ed.)
5. Life Cycle Assessment (LCA) 102: Electric Vehicle (EV) Global Warming Benefits - A Comprehensive Methodology for Evaluation, John Beath, Paula Vosmus, Denise Grubert, Sarah Backes.
6. Life Cycle Assessment: Future Challenges, Surjya Narayana Pati, CRC Press.
7. Age of Auto Electric: Environment, Energy, and the Quest for the Sustainable Car, Matthew N. Eisler.
8. Electric Vehicle Propulsion Drives and Charging Systems, 1st Edition, Kundan Kumar, Ambrish Devanshu, Sanjeet K. Dwivedi, CRC Press.
9. Electric and Hybrid Vehicle (Green and Sustainable Transportation), Dr. Nitesh Tiwari & Dr. Shekhar Yadav.
10. Kamboj, Neha, Vinita Choudhary, and Sonal Trivedi. "Life Cycle Analysis of Electric Vehicles." In Business Drivers in Promoting Digital Detoxification, pp. 209-225. IGI Global Scientific Publishing, 2024.

Semester-II

Elective II

Automotive Testing and Certification for EV [PEC-571-MEV-B]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PEC-571-MEV-B	3	50	50	-	-	100	3

1. **Introduction to Vehicle Regulations and Homologation**
   Need for Vehicle Testing and Homologation: Understanding the necessity for safety, performance, and environmental compliance; Regulatory Overview: Study of key international and national regulations and standards bodies; International: ECE (Economic Commission for Europe), SAE (Society of Automotive Engineers); National (e.g., India): AIS (Automotive Industry Standards), CMVR (Central Motor Vehicles Rules), Bharat EV norms; Other: FMVSS (Federal Motor Vehicle Safety Standards), ISO 26262 (Functional Safety); Type Approval and Certification Schemes: Processes for type approval, self-certification, and conformity of production (CoP); Vehicle Classification: Understanding different categories (e.g., M, N, O categories of vehicles) for regulatory purposes.

2. **Battery System Testing and Safety**
   Battery Performance Testing: Evaluation parameters: Voltage, current, temperature, state of charge (SoC), state of health (SoH), energy, and power estimation; Performance criteria: Efficiency, heat generation, capacity, and life cycle testing; Battery Safety and Abusive Testing, Standards: Testing as per AIS 048, ECE R100, and USABC, Tests: Nail penetration, overcharge, over-discharge, short circuit, thermal abuse, and crash simulation; Battery Management System (BMS) Validation: Testing functionality including cell balancing (active/passive), fault detection, diagnostics, and thermal control interfaces.

3. **Electric Motor, Drivetrain, and Power Electronics Testing**
   Motor Characterization: Performance metrics: Net power, torque, speed, and efficiency measurements as per standards like AIS 041 and ECE R85; Durability and overload capacity: Testing motor performance under various operating conditions; Power Electronics and Inverter Testing: Validation of DC-DC converters, inverters, and motor controllers for efficiency and reliability; Regenerative Braking Testing: Evaluation of energy recovery systems and their performance.

4. **Vehicle Performance and Environmental Testing**
   Vehicle Performance on Dynamometers and Test Tracks: Energy Consumption: Measurement as per standards like AIS 039 and ECE R101; Electric Range: Determination of range under standard test cycles as per AIS 040 and ECE R101; Other tests: Power at wheels, gradeability, and braking performance; NVH (Noise, Vibration, and Harshness) Testing: Standard methods for measuring noise inside and outside the vehicle, identifying sources, and pass-by noise testing; Environmental Simulation: Lab simulations for testing EV components and systems under varying environmental conditions like temperature and humidity. Automotive safety components certification by various organizations (ARAI, SIAM, SAE, ASME, FMVSS).

5. **Charging Testing and Safety Protocols**
Charger Testing and Certification: Standards: Testing as per AIS 138, Bharat EV Charger specifications (AC001 and DC001), CHAdeMO, and CCS protocols; Interoperability: Ensuring compatibility between vehicles and various charging stations; Grid Integration (V2G) Testing: Evaluation of vehicle-to-grid communication and power flow; High-Voltage Safety: Protocols and testing for electrical safety, isolation sensing, and shock prevention (e.g., OSHA, NFPA 70E compliance); Crashworthiness: Safety considerations and testing for EV specific components (e.g., battery pack integrity during impact).

References:

1. Advanced automotive fault diagnosis: automotive technology: vehicle maintenance and repair. Tom Denton, Routledge, 2020.
2. Electric and hybrid vehicles: design fundamentals. Iqbal Husain, CRC press.
3. Hybrid electric vehicles: principles and applications with practical perspectives, Mi Chris, and M. Abul Masrur, John Wiley & Sons, 2025.
4. https://araiindia.com
5. https://emobility.araiindia.com
6. https://hmr.araiindia.com/api/AISFiles/6_AIS_123_Part%203_with_Amd_1,2,3%20and%204_F_f49ca871-c9f5-4ae5-a52b-e6674f007b54.pdf
7. https://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf
8. https://niti.gov.in/content/national-mission-transformative-mobility-and-battery-storage
9. https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf

Semester-II

Elective II

Simulations of Transmission systems for EV [PEC-571-MEV-C]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><td>CCE*</td><td>End Semester Assessment</td></tr>
<tr><td>PEC-571-MEV-C</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
</table>

1. **Introduction to Electric Vehicles and Powertrain Architecture**
   EV Fundamentals: Types of EVs (BEV, HEV, PHEV, FCEV), their architecture, and key components; Vehicle Dynamics: Forces acting on a vehicle (rolling resistance, aerodynamic drag, grading resistance), dynamic equations, drive cycles, and performance parameters (max speed, acceleration, gradeability); Powertrain Components: Traction motors (PMSM, Induction, SRM), power flow in EV powertrains, and energy management strategies; Transmission Role in EVs: Rationale for single-speed and multi-speed transmissions in EVs (e.g., Porsche Taycan's two-speed gearbox).

2. **EV Transmission Systems Design and Modeling**
   Transmission Types: Design of gear systems (spur, helical, planetary gears), clutches, and differentials for EV applications; Modeling Techniques: Mathematical modeling of mechanical components (gears, shafts, bearings, brakes, etc.);System Integration: Integration of electric motor models and mechanical transmission models; Control Strategies: Gear shifting control strategies for multi-speed transmissions and torque vectoring.

3. **Simulation Tools and Methodologies**
   Simulation Software: Introduction to industry-standard tools (MATLAB/Simulink, ANSYS, AVL, etc.) for EV simulations; Modeling and Simulation Methods: Physics-based modeling and empirical approaches, System-level simulation for performance analysis (speed, torque, efficiency), Component-level simulation for detailed analysis of mechanical components (gears, brakes, and bearings, etc.), Hardware-in-the-Loop (HIL) and Software-in-the-Loop (SIL) concepts, Data Acquisition: Use of real-world drive cycle data for simulation inputs; Transmission Control Unit (TCU) Fundamentals: Hardware-in-the-Loop (HIL) simulation and testing of TCU logic; Regenerative Braking Integration: Modeling the interaction between mechanical braking and regenerative braking through the transmission system..

4. **Performance and NVH Analysis**
   Efficiency Analysis: Simulating power losses in gears, bearings, and lubrication systems to optimize overall efficiency; NVH (Noise, Vibration, and Harshness): Dynamic modeling of gear systems and power train torsional responses, Analysis of motor excitation and its impact on transmission vibration, Simulation of housing vibration responses using finite element models (FEM), Techniques for minimizing gear rattle and whine, Shift Strategy Optimization: Development and simulation of optimal gear shifting schedules for performance, efficiency, and smoothness; Performance Evaluation and Validation: Analyzing simulation results against performance metrics (acceleration time, top speed, range, efficiency) and experimental data.

5. **Advanced Topics and Case Studies**
Optimization of Transmission Ratios: Using optimization algorithms (e.g., genetic algorithms) to select optimal gear ratios for performance and efficiency; Thermal Management: Modeling and simulation of transmission oil cooling systems; Functional Safety: Overview of ISO 26262 standards as applied to powertrain components and their simulation; Case Studies/Projects: Real-world case studies of commercial EVs (e.g., Tesla Roadster, Porsche Taycan) and mini-projects involving modeling and simulating a specific EV transmission system; Performance Evaluation and Validation: Analyzing simulation results against performance metrics (acceleration time, top speed, range, efficiency) and experimental data.

References:

1. Automotive Power Transmission Systems, Yi Zhang and Chris Mi, Wiley.
2. Modeling for Hybrid and Electric Vehicles Using Simscape, Shuvra Das.
3. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach, Amir Khajepour M. Saber Fallah, Avesta Goodarzi, John Wiley & Sons.
4. Electric Drive System Design for Electric Vehicles,Yunqi Zheng, CRC Press.
5. Noise, Vibration and Harshness of Electric and Hybrid Vehicles, SAE International
6. NVH Analysis Techniques for Design and Optimization of Hybrid and Electric Vehicles, Parizet, Etienne, Karl Janssens, Pedro Poveda-Martínez, Andreia Pereira, Jakub Lorencki, and Jaime Ramis-Soriano.
7. Noise and Torsional Vibration Analysis of Hybrid Vehicles. Tang, Xiaolin, Yanjun Huang, Hong Wang, and Yechen Qin, Morgan & Claypool.
8. Noise, Vibration and Harshness of Electric and Hybrid Vehicles, Lijun, Zhang & Dejian, Meng & Gang, Chen.
9. https://www.eai.in/blog/2018/12/electric-vehicle-transmission-system-ev-transmission-gears-powertrain.html
10. Transmission Design and Control Optimization of an Electric Vehicle Using Analytical Modeling Methods Olaf Borsboom, Thijs de Mooy, Mauro Salazar, Theo Hofman, IFAC-PapersOnLine.
11. Multi-Speed Transmission Optimization of Electric Vehicles Based on Shifting Pattern Considering Dynamic Inertia Efficiency, K. Park, S. -K. Lim and K. Kwon, IEEE Access.
12. Design Optimization of the Transmission System for Electric Vehicles Considering the Dynamic Efficiency of the Regenerative Brake, Zhao, B., Lv, C., Hofman, T., Steinbuch, M. SAE Technical Paper.

Semester-II

Elective II

Power Electronics for EVs [PEC-571-MEV-D]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><td>PEC-571-MEV-D</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
</table>

1. **Introduction to Electric Vehicles and Power Electronics Fundamentals**
   EV Architectures: Classification (BEV, HEV, PHEV), comparison with IC engine vehicles, and vehicle dynamics; Role of Power Electronics: Function in energy conversion and power flow; Basic Power Electronic Devices: Characteristics of power semiconductor switches (Diodes, Thyristors, BJTs, MOSFETs, IGBTs); Device Characteristics and Protection: Driver circuits, sensing, and thermal management.

2. **DC/DC Converters in EVs**
   Basic Principles: Buck, Boost, and Buck-Boost converters; Isolated Converters: Topologies like flyback, forward, and half-bridge; Four-Quadrant Operation: Bidirectional converters for regenerative braking; Control Techniques: Feedback control, voltage mode, current mode, and converter modeling.

3. **Rectifiers and AC/DC Conversion**
   Single-Phase and Three-Phase Rectifiers: Analysis of diode rectifiers; Active Front-End Rectifiers: Controlled AC-DC conversion for grid integration and V2G; Power Factor Correction (PFC): Techniques for efficient charging ; On-Board and Off-Board Charging Systems: Types (AC, DC fast charging) and standards (CHAdeMO, CCS, Bharat EV norms).

4. **Inverters and Motor Drives**
   Single-Phase and Three-Phase Inverters: Voltage Source Inverters (VSI) principles; Modulation Techniques: PWM, SPWM, and SVPWM for motor control; EV Motor Drives: Operation and control of various motors (DC, Induction, BLDC, PMSM, SRM); Motor Control Strategies: Vector control, direct torque control, and four-quadrant operation.

5. **Battery Management Systems (BMS) and Integration**
   BMS Functions: Sensing (voltage, temperature, current, isolation) and fault detection; Cell Balancing: Passive and active techniques for battery life and efficiency; State Estimation: Methods for SoC, SoH, and RUL estimation; System Integration: Power flow management between battery, converters, motor drive, and VCU; high-voltage safety; Vehicle-to-Grid (V2G) and Grid Integration: Concepts, challenges, and the role of power electronics.

References:

1. Power Electronics for Electric Vehicles and Energy Storage Emerging Technologies and Developments, Dharavath Kishan, Ramani Kannan, B Dastagiri Reddy, Prajof Prabhakaran, CRC Press.
2. Power Electronics: Converters, Applications, and Design, Ned Mohan.
3. Fundamentals of Power Electronics, Robert W. Erickson.
4. Power Electronics: Essentials & Applications, L. Umanand.
5. Battery Management Systems: Design and implementation for EVs, Adrian Cellar.
6. Power Electronics: EV Battery and Charging Systems: Mastering Battery and Charging Systems for Electric Vehicles, Valentina Riddell.
7. Handbook of Power Electronics in Autonomous and Electric Vehicles, Muhammad H. Rashid.

Semester-II

Elective III

Charging Infrastructure for EV [PEC-572-MEV-A]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PEC-572-MEV-A	3	50	50	-	-	100	3

1. **Introduction to EV Charging Technologies**
   Types of Electric Vehicles (BEVs, HEVs, PHEVs), Overview of EV components (battery, power electronics, motor), Charging types: AC vs. DC charging, normal power vs. high power charging, Charging levels and modes (Level 1, 2, 3), Battery Swapping Stations (BSS). On-board & off-board charging, The Fast-Charging Process, Fast Charging Strategies, The Fast Charger Configuration, Using Equalizing/Leveling Chargers, Inductive Charging-Making Recharging Easier, Range Testing of Electric Vehicles Using Fast Charging, Electric Vehicle Speedometer Calibration. Wireless Charging.

2. **Power Electronics for EV Charging**
   Power electronic converters for battery charging (AC-DC rectifiers, DC-DC converters), Single-phase and three-phase configurations, Bidirectional converters for V2G (Vehicle-to-Grid) applications, Fundamentals of power electronics for efficient charging.

3. **Standards, Protocols, and Safety**
   EV charger standards (Bharat EV Charger specifications AC001 and DC001, CCS, CHAdeMO, Type 2, etc.), Communication protocols (OCPP, ISO 15118, CAN), Safety standards and testing procedures (AIS 048, ECE R100), Interoperability and eRoaming challenges

4. **Grid Integration and Infrastructure Planning**
   Impact of EV charging on the power network (grid stability, power quality issues, congestion management), Grid integration strategies: Smart charging, Types of Smart Charging, Smart Charging Enablers, Enabling smart charging in India, Benefits and disadvantages of smart charging, cost analysis of smart charging stations, ToU charging and uncontrolled charging, managed charging, and V2G technology, Economic Analysis of EV charging infrastructure integration, Grid Upgradation, Low Voltage Distribution System (LVDS), High Voltage Distribution System (HVDS), Renewable energy integration with charging stations (solar PV, energy storage systems), Planning and optimal deployment of public and private charging infrastructure.

5. **Policies, Business Models, and Case Studies**
   Indian EV Statistics and Charging Infrastructure, 2W, 3W, 4W, EV Demand in India, E-Bus Demand in India, EV Charger Infrastructure in India, EV models available in the Indian Market, Government policies and regulatory framework in India (FAME II, MoP guidelines, state policies),

Business models for Charge Point Operators (CPOs) and service providers Payment mechanisms for EV charging, Case studies of successful infrastructure deployments

References:

1. Power Electronics: Converters, Applications, and Design, Ned Mohan, Tore M. Undeland, and William P Robbins.
2. Fundamentals of Power Electronics, Robert W. Erickson and Dragan Maksimovic
3. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Husain.
4. Automotive Electrical and Electronic Systems, Tom Denton.
5. Electric Vehicle Charging System, Ms. M. Aruna, Dr. V. Srividhya, Mr. G. Shasikanth.
6. https://www.niti.gov.in/sites/default/files/2023-05/Final-smaller_Electric-Vehicles-Charging-Infrastructure.pdf

Semester-II

Elective III

Artificial Intelligence in EV [PEC-572-MEV-B]

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<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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1. **Introduction to artificial intelligence-empowered electric vehicles in smart grids**
   AI in Smart Grid (SG) Integration, Distributed Energy Resources (DERs), relation between the car and the grid, Cost Minimization: AI algorithms (often Reinforcement Learning), Peak Demand Reduction, Renewable Integration, The "Intelligence" of the EV (in Manufacturing and Self Driving); Communication technologies for electric vehicles, Robustness and resilience of artificial intelligence enabled electric vehicles: "a safety and security perspective"; Applications of AI-empowered electric vehicles for voice recognition in Asian and Austronesian languages.

2. **Energy management for artificial intelligence empowered modern electric vehicles**
   Demand response management using artificial intelligence-empowered electric vehicles, Energy prediction for future energy supply in electrical vehicles, Optimizing the integration of renewable energy source and plug-in electric vehicles for economic emission load dispatch through soft computing techniques, Battery-operated electric vehicles and plug-in hybrid electric vehicles.

3. **Energy trading for artificial intelligence empowered modern electric vehicles** Peer-to-peer energy trading using renewable energy sources and electric vehicles, Smart energy management using vehicle-to-vehicle and vehicle-to-everything, Vehicle-to-vehicle power transfer, Cyber-security challenges for artificial intelligence empowered electric vehicles—analysis and current status.

4. **Case studies and futuristic trends for artificial intelligence-enabled electric vehicles**
   Revitalizing traffic control: the synergy of fog computing and Internet of Things for an intelligent traffic light system for electric vehicles, On fuzzy completely irresolute on smart decision-making for electric vehicle systems, Front-in parking method for intelligent electric vehicles using proportional integral derivative control, The futuristic trends for modern electric vehicles, Environmental sustainability and carbon footprint reduction through artificial intelligence-enabled energy management in electric vehicles

References:

1. Artificial Intelligence-Empowered Modern Electric Vehicles in Smart Grid Systems: Fundamentals, Technologies, and Solutions, Aparna Kumari and Sudeep Tanwar, Elsevier.
2. Smart Electric and Hybrid Vehicles: Design, Modeling, and Assessment by Industry 4.0 Approaches by Ajay Kumar et al. CRC Press.
3. Artificial Intelligence Applications in Battery Management Systems and Routing Problems in Electric Vehicles by S. Angalaeswari, T. Deepa, and L. Ashok Kumar, IGI Global.
4. AI-powered smart grids in the 6G era: A comprehensive survey on security and intelligent energy systems. Sanjalawe, Y., Fraihat, S., Makhadmeh, S.N. and Alzubi, E. IEEE Open Journal of the Communications Society,

Semester-II

Elective III

Advanced CFD for Battery Thermal Management [PEC-572-MEV-C]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
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<tr><td>PEC-572-MEV-C</td><td>3</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>3</td></tr>
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1. **Fundamentals of Battery Thermal Behavior**
   Basic electrochemistry and heat generation in lithium-ion batteries, Thermal runaway mechanisms and safety considerations, Operating temperature ranges and their impact on battery performance and life span.

2. **Advanced CFD Theory:**
   Review of governing equations (Navier-Stokes, energy, etc.), Numerical methods (Finite Volume Method, Finite Difference Method), Grid generation techniques and mesh quality assessment, Turbulence modeling (RANS, LES, etc.), Multiphase flow and heat transfer phenomena, if relevant to advanced cooling methods.

3. **CFD Modeling of Battery Systems:**
   Modeling approaches: cell level, module level, and pack level, Coupled thermal-electrochemical modeling (e.g., Newman P2D model, Equivalent Circuit Model (ECM), MSMD method), Implementation of heat generation models (Joule heating, reaction kinetics) in CFD software (e.g., ANSYS Fluent, OpenFOAM, COMSOL).Validation of simulation results against experimental data.

4. **Battery Thermal Management Systems (BTMS) Analysis:**
   Design and analysis of various cooling strategies: Air cooling and liquid cooling systems. Phase Change Materials (PCM) based systems. Heat pipes and advanced cooling techniques using nanofluids. Optimization of BTMS designs for efficiency, weight, and cost.

5. **EV Aerodynamics and Efficiency**
   CFD to minimize aerodynamic drag for extending an EV's range; External Aerodynamics: Forces and moments on the vehicle (drag, lift, side forces), Modeling flow around the full vehicle body and components (e.g., wings, spoilers, tires), Shape optimization for drag reduction; Internal Aerodynamics: Optimizing transmission lubrication systems using oil flow CFD simulations to minimize churning losses. CFD samples related to radiators and HVAC systems.

References:

1. Computational Fluid Dynamics: The Basics with Applications,John D. Anderson
2. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H.K. Versteeg and W. Malalasekera
3. Electric and Hybrid Vehicles – Design Fundamentals, Iqbal Husain
4. Modern Electric, Hybrid Electric and Fuel Cell Vehicles - Fundamentals - Theory and Design, Mehrdad Ehsani, et al.

Semester-II

Elective III

Autonomous Vehicle Technologies [PEC-572-MEV-D]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
PEC-572-MEV-D	3	50	50	-	-	100	3

1. **Automotive Embedded Systems and Sensor Technology**
   Overview of automotive embedded systems architecture (chassis, body, driveline); Study of various sensors: LiDAR, RADAR, cameras, ultrasonic, GPS/IMU, speed, and temperature sensors; Sensor working principles, specifications, signal processing circuits, and microcontroller interfacing; Introduction to in-vehicle networking and communication protocols (CAN, Ethernet, FlexRay).

2. **Perception, Localization, and Sensor Fusion**
   Perception: Computer vision techniques for object detection, recognition, tracking, and image segmentation using deep learning models (e.g., CNNs); Localization: Principles of GNSS (Global Navigation Satellite Systems) and simultaneous localization and mapping (SLAM); Sensor Fusion: Techniques for integrating data from multiple sensors to create a robust and accurate environment model.

3. **Motion Planning and Control Systems**
   Motion Planning: Path and speed planning, trajectory optimization, and reactive control strategies for safe navigation; Control Systems: Design of longitudinal and lateral controllers (e.g., adaptive cruise control, lane centering assist); Model-based control systems design using tools like MATLAB and Simulink; Vehicle dynamics and stability analysis in the context of autonomous control.

4. **Machine Learning and Artificial Intelligence for AVs**
   Introduction to machine learning (ML) and AI techniques for autonomous systems; Deep learning architectures (e.g., neural networks, reinforcement learning) for decision-making and perception tasks; Probabilistic methods for uncertainty estimation; Applications of AI in system monitoring, fault detection, and energy management for autonomous electric vehicles.

5. **Safety, Security, Ethics, and Testing**
   Safety & Reliability: Implementation of fail-safe mechanisms, redundancy, Fault Detection and Isolation (FDI), and risk assessment techniques; Overview of relevant safety standards (e.g., ISO 26262); Security: Cyber security threats and protective measures for connected and autonomous vehicles; Ethics & Law: Discussion of ethical considerations, liability issues, and regulations surrounding AV deployment; Testing: Integration and testing methodologies, simulation techniques, and validation procedures for functional AV systems.

References:

1. Self-Driving Vehicles and Enabling Technologies by Marian Găiceanu. Published by Intech Open.
2. Connected and Automated Vehicles: Infrastructure, Applications, Security, Critical Challenges, and Future Aspects by Memoona Sadaf, et al. Published by Elsevier.
3. Electric Vehicle Engineering by Per Enge, Nick Enge, and Stephen Zoepf. Published by McGraw-Hill.
4. Electric and Hybrid Vehicles: Technologies, Modeling and Control – A Mechatronic Approach by Amir Khajepour, M. Saber Fallah, and Avesta Goodarzi. Wiley.
5. Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives by Chris Mi, M. Abul Masrur, and David Wenzhong Gao. Wiley.
6. Computer Vision: Algorithms and Applications by Richard Szeliski. Springer.
7. Deep Learning by Yoshua Bengio, Ian Good fellow, and Aaron Courville. Published by MIT Press.

Seminar – I, II, and III

[SEM-580-MEV, SEM-603-MEV, SEM-651-MEV]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	Lect. /Week	Paper		TW	Oral/ Presentation	Total	
		CCE*	End Semester Assessment				
SEM-580-EVT	4	-	-	25	25	50	2
SEM - 603-EVT	6	-	-	25	25	50	3
SEM - 651-EVT	8	-	-	50	50	100	4

Assessment of the Seminar has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR SEMINAR REPORT WRITING

It is important that the procedures listed below be carefully followed by all the students of M.E. (Mechanical Engineering).

1. Prepare 3 **COPIES** of your manuscript.
2. Limit your project report to preferably
   a) 15-20 manuscript pages for Seminar I
   b) 20-25 manuscript pages for Seminar II
   c) 25-30 manuscript pages for Research Project Based Seminar
3. The footer must include the following:
   Institute Name, M. E. (Mechanical) (Design Engineering) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.
5. Print the manuscript using
   a) Letter quality computer printing.
   b) The main part of manuscript should be Times New Roman 12 pt. and justified**.**
   c) Use 1.5 line spacing.
   d) Entire report shall be one chapter. No chapters for Seminar I, II and III.
   e) Seminar I shall not have last section as Conclusions; it will be summary only.
6. Use the paper size **8.5'' × 11''** or **A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each paragraph will begin without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from internet are not acceptable.**
    a) Illustrations should not be more than **two** per page. One could be ideal
    b) Figure No. and Title at bottom with **12 pt**
    c) Legends below the title in **10 pt**
    d) Leave proper margin in all sides
    e) Illustrations as far as possible should not be xeroxed.

11. **Photographs** if any should be of glossy prints
12. Please use **SI** system of units. If students would like to add the equivalent in inch- pound (British) units, they must be stated in parenthesis after the **SI** units. In case the final result comes out in any other units (say due to empirical formula etc.) covert the unit to **SI** unit.
13. Please **number the pages** on the front side, centrally below the footer
14. **References** should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. **Symbols** and **notations** if any should be included in nomenclature section only
16. Following will be the order of report
    i. **Cover page** and **Front page** as per the specimen on separate sheet
    ii. **Certificate** from the Institute as per the specimen on separate sheet
    iii. **Acknowledgement**
    iv. **List of Figures**
    v. **List of Tables**
    vi. **Nomenclature**
    vii. **Contents**
    viii. **Abstract** (A brief abstract of the report not more than **150 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre.** The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in the Abstract)
    ix. Section: Introduction
    x. References
17. All section headings and subheadings should be numbered. For sections use numbers **1, 2, 3, ….** and for subheadings **1.1**, **1.2**, **….** etc and section subheadings **2.1.1**, **2.1.2, ….** etc.
18. **References** should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If **figures** and **tables** are taken from any reference then indicate source of it. Please follow the following procedure for references

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pp. 34 – 40.

Reports, Handbooks etc.

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002.

ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent

Patent no, Country (in parenthesis), date of application, title, year.

Internet

www.(Site) [Give full length URL]

Format for front page and Certificate

A Seminar I / II / III (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide (TNR, 16pt, Centrally Aligned)

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering

Name of the Institute

[2025-26] (TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Logo

C E R T I F I C A T E

This is to certify that *Mr/Mrs*……………......, has successfully completed the seminar- I/II/III entitled "Performance analysis of……" under my supervision, in the partial fulfillment of Master of Engineering-Mechanical (Electric Vehicle Technology) of Savitribai Phule Pune University, Pune.

Date:

Place:

Guide's Signature
Guide Name

Head
Department and Institute Name

External Examiner

Seal

Principal, Institute Name

Savitribai Phule Pune University, Pune

Maharashtra, India

ME – Mechanical (Electric Vehicle Technology)

Semester III

Semester – III

Research Methodology [RM-601-MEV]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHING SCHEME</th><th colspan="5">EXAMINATION SCHEME</th><th>CREDITS</th></tr>
<tr><th rowspan="2">Lect. /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th><th rowspan="2"></th></tr>
<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>RM-601-MEV</td><td>5</td><td>50</td><td>50</td><td>-</td><td>-</td><td>100</td><td>5</td></tr>
</table>

1. **Introduction**
   Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Criteria of Good Research

2. **Research Problem and Research Design:**

   Definition of good research problem, Feasibility study of research problem, Importance of research problem, Sources of research problem, Criteria of good research problem, Meaning of Hypothesis, Characteristics of Hypothesis, Errors in selecting a research problem, Concept & need of research design, Meaning of variable, Selection of variables

3. **Mathematical Modelling and prediction of performance:**
   Steps in Setting up a computer model to predict performance of experimental system, Validation of results, multi-scale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity analysis.

4. **Basic instrumentation:**
   Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP in data collection in noisy environment, good measurement practice.

5. **Applied statistics:**

   Regression analysis, curve fitting and developing Correlation, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis, Probable errors in the research, Error analysis and methods to reduce errors in research process.

6. **Research report writing and Publication**

   Research Report: Dissemination of research findings, outline and structure of research report, different steps and precautions while writing research report, methods and significance of referencing

Publishing Research work: Selection of suitable journal for publishing research work, Open access Vs Subscription Journals, identifying indexing of selected journals, Impact factor of the journal, structure of research paper, Check for plagiarism of the article, Research paper submission and review process.

Lab Practice:

1. Write Sample research proposal of the planned research topic giving details of topic, significance, funding required etc.
2. Write a research paper on review of at least 5 research papers for a research topic (Language, formatting and authors guidelines to be strictly followed from standard Springer or Elsevier Journals and referred journal details to be mentioned in the Lab practice file) and verify the research article for plagiarism and attach the plagiarism report.

Reference Books:

1. Research methodology: An Introduction for Science & Engineering students, by Stuart Melville and Wayne Goddard
2. Research Methodology: Methods and Trends, by Dr. C. R. Kothari
3. Research Methodology: An Introduction by Wayne Goddard and Stuart Melville
4. Research Methodology: A Step-by-Step Guide for Beginners, by Ranjit Kumar, 2nd Edition
5. Operational Research by Dr. S.D. Sharma, Kedar Nath Ram Nath & Co.
6. Software Engineering by Pressman

Semester - III

On Job Training/ Internship [OJT-602-MDE]

<table>
<tr><th rowspan="3">CODE</th><th>TEACHIN G SCHEM E</th><th colspan="5">EXAMINATION SCHEME</th><th rowspan="3">CREDITS</th></tr>
<tr><th rowspan="2">Practical (Hrs.) /Week</th><th colspan="2">Paper</th><th rowspan="2">TW</th><th rowspan="2">Oral/ Presentation</th><th rowspan="2">Total</th></tr>
<tr><th>CCE*</th><th>End Semester Assessment</th></tr>
<tr><td>OJT-602-MDE</td><td>10</td><td>-</td><td>-</td><td>100</td><td>--</td><td>100</td><td>5</td></tr>
</table>

Course objectives:

1. To put theory into practice and expand thinking and broaden the knowledge and skills acquired through coursework in the field.
2. To relate to, interact with, and learn from current professionals in the field.
3. To understand and adhere to professional standards in the field.
4. To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
5. To develop the initiative and motivation to be a self-starter and work independently.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **Gain** practical experience within industry in which the internship is done.
- **Acquire** knowledge of the industry in which the internship is done.
- **Apply** knowledge and skills learned to classroom work.
- **Develop** and refine oral and written communication skills.
- **Acquire** the knowledge of administration, marketing, finance and economics.

Course Description:

1. Internship/On Job Training provide students the opportunity of hands-on experience that in- cludes personal training, time and stress management, interactive skills, presentations, budget- ing, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.
2. An internship is the phase of time for students when they are trained for their skills, they are good at, and it gives them a chance to apply their knowledge practically in industries
3. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute.
4. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship.

Guidelines

- **Purpose**

  Internships are designed to bridge the gap between academic learning and industry practice. They aim to provide hands-on experience, expose students to the industrial environment, develop technical and soft skills (communication, teamwork, problem-solving), and help in career exploration.

- **Internship Duration and Academic Credentials**

  - Students can take internship work in the form of Online/Offline mode from any of the Industry / Government Organization Internship Programmes approved by SPPU/AICTE/UGC portals
  - An intern is expected to spend 10 - 12 hours per week on the Internship. Training will result in about 160-170 hours of total internship duration.
  - The minimum requirement regarding Internship duration should not be below 8 weeks

- **Type of Internship**

  - Industry/Government Organization Internship: Working directly with a company or government body.
  - Research Internship: Focused on research projects, often in collaboration with academic institutions or R&D labs.
  - Innovation/Entrepreneurship: Working on developing new products, processes, or even starting a venture.
  - Social Internship: Engaging in community-based projects.

- **Assessment Details (TW and Practical)**

  - Term work for 100 marks
  - A daily log submitted by the student and a work log signed by the office HoDs where the student has interned will be considered towards the TW marking.

- **Indicative list of areas for OJT**

  - Trade and Agriculture
  - Economy & Banking Financial Services and Insurance
  - Logistics, Automotive & Capital Goods
  - Fast Moving Consumer Goods & Retail
  - Information Technology/Information Technology Enabled Services & Electronics
  - Handcraft, Art, Design & Music
  - Healthcare & Life Science

- Sports, Wellness and Physical Education
- Tourism & Hospitality
- Digitization & Emerging Technologies (Internet of Things / Artificial Intelligence / Machine
- Learning / Deep Learning / Augmented Reality / Virtual Reality etc.)
- Humanitarian, Public Policy and Legal Services
- Communication
- Education
- Sustainable Development
- Environment
- Commerce, Medium and Small-Scale Industries

- **Faculty Supervision:** Students are usually assigned an internal faculty guide/mentor who supervises their internship activities. This faculty member acts as a teacher, mentor, and critic, and ensures the internship aligns with academic goals. External Supervision: In many cases, an external expert from the host organization also guides the student.

- **Documentation and Reporting:**
  - Joining Report: To be submitted within a specified time frame (e.g., one week from joining).
  - Daily/Periodical Diary: Students are often required to maintain a daily or weekly record of their observations, work, and learning.
  - Internship Report: A comprehensive report detailing the work done, learning outcomes, and achievements during the internship. This report needs to be duly signed by the company official and the faculty mentor.
  - Completion Certificate: Issued by the host organization upon successful completion.

- **Evaluation:**
  - Evaluation is typically done by the institute, often within a short period after the internship ends.
  - It may involve presentations, viva-voce examinations, and assessment of the internship report and daily diary.
  - Performance-based feedback from the industry mentor is usually a key component.

Project Stage – I and II [RPR-604-MDE, RPR-652-MDE]

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
	RP Hrs./ Week	Paper		TW	Oral/ Presentation	Total	
		In Semester Assessment	End Semester Assessment				
RPR-604-MDE	18	-	-	25	25	50	9
RPR-652-MDE	36	-	-	150	50	200	18

Assessment of Project Stage-I/II has to be carried out as per R-1.4 and R-1.5 of PG Rules and Regulations of Credit System.

INSTRUCTIONS FOR DISSERTATION WRITING

It is important that the procedures listed below be carefully followed by all the students of M.E. (Mechanical Engineering).

1. Prepare **Three Hard Bound Copies** of your manuscript.
2. Limit your Dissertation report to 80 – 120 pages (preferably)
3. The footer must include the following:
   Institute Name, M.E. (Mechanical) (Design Engineering) Times New Roman 10 pt. and centrally aligned.
4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned.
5. Print the manuscript using
   a. Letter quality computer printing.
   b. The main part of manuscript should be Times New Roman 12 pt. with alignment - justified**.**
   c. Use 1.5 line spacing.
   d. Entire report shall be of 5- 7 chapters.
   e.
6. Use the paper size **8.5’’ × 11’’** or **A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5’’ × 11’’	Paper A4 (210 × 197 mm)
Top	1’’	25.4 mm
Left	1.5’’	37 mm
Bottom	1.25’’	32 mm
Right	1’’	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, **black and white. Illustrations downloaded from internet are not acceptable.**
    a. Illustrations should not be more than **two** per page. One could be ideal
    b. Figure No. and Title at bottom with **12 pt**
    c. Legends below the title in **10 pt**
    d. Leave proper margin in all sides
    e. Illustrations as far as possible should not be photo copied.

11. **Photographs** if any should of glossy prints
12. Please use **SI** system of units only.
13. Please **number the pages** on the front side, centrally below the footer
14. **References** should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. **Symbols** and **notations** if any should be included in nomenclature section only
16. Following will be the order of report
    i. **Cover page** and **Front page** as per the specimen on separate sheet
    ii. **Certificate** from the Institute as per the specimen on separate sheet
    iii. **Acknowledgements**
    iv. **List of Figures**
    v. **List of Tables**
    vi. **Nomenclature**
    vii. **Contents**
    viii. **Abstract** (A brief abstract of the report not more than **150 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre.** The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in Abstract

1. **Introduction** (2-3 pages) (TNR – 14 Bold)
1.1 Problem statement (TNR – 12)
1.2 Objectives
1.3 Scope
1.4 Methodology
1.5 Organization of Dissertation

2. **Literature Review** (20-30 pages)
Discuss the work done so far by researchers in the domain area and their significant conclusions. No derivations, figures, tables, graphs are expected.

3. This chapter shall be based on your own simulation work (Analytical/ Numerical/FEM/CFD) (15- 20 pages)

4. Experimental Validation - This chapter shall be based on your own experimental work (15-20 pages)

5. **Concluding Remarks and Scope for the Future Work** (2-3 pages)

References

ANNEXURE (if any)

(Put all mathematical derivations, Simulation program as Annexure)

17. All section headings and subheadings should be numbered. For sections use numbers **1, 2, 3, ….** and for subheadings **1.1**, **1.2**, **….** etc and section subheadings **2.1.1**, **2.1.2, ….** etc.

18. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If **figures** and **tables** are taken from any reference then indicate source of it. Please follow the following procedure for references

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Patent

Patent no, Country (in parenthesis), date of application, title, year.

Internet

www.(Site) [Give full length URL]

A Project Stage -I Report on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned, Title Case)

By (TNR, 16pt, Centrally Aligned)

Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guide

Guide's Name (TNR, 16pt, Centrally Aligned)

Institute Logo

Department of Mechanical Engineering

Name of the Institute

[2026-27]

(TNR, 22pt, Title Case Centrally Aligned)

Name of the Institute

Logo

C E R T I F I C A T E

This is to certify that *Mr/Mrs*……………......, has successfully completed the Project Stage - I entitled "Performance analysis of……" under my supervision, in the partial fulfillment of Master of Engineering-Mechanical (Electric Vehicle Technology) of Savitribai Phule Pune University, Pune.

Date:

Place:

Guide's Signature
Guide Name

Head
Department and Institute Name

External Examiner

Seal

Principal, Institute Name

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Principal, Institute Name

Task Force for Curriculum Design and Development

Program Coordinator

Team Members for Course Design

Sr. No.	Name of the Team Member
1	
2	
3	
4	
5	

Chairman

Dr. Pradeep Patil - Board of Studies Mechanical Engineering

Savitribai Phule Pune University, Pune

Dean

Dr. Raosaheb Vikram Latpate - Dean – Science and Technology

Savitribai Phule Pune University, Pune