

AMRUTVAHINI COLLEGE OF ENGINEERING, SANGAMNER

Department of Electrical Engineering

Honors in Electric Vehicle (18 Credits)

Year	Semester	Course Code	Course Name	Credits
Second Year	Sem III	R25-EE-HOC-201	E-Mobility	3
	Sem IV	R25-EE-HOC-202	Battery Management System	3
Third Year	Sem V	R25-EE-HOC-301	Electric Vehicle Charging System	3
	Sem VI	R25-EE-HOC-302	Advanced Electric Drives for E-Mobility	3
Final Year	Sem VII	R25-EE-HOC-401	Electric Vehicle Testing	3
	Sem VIII	R25-EE-HOC-402	Autonomous Vehicle	3



Dr. S. S. Kadlag
BoS Chairman

Program:	S. Y. B. Tech (Electrical Engineering)			Semester:	III		
Course:	E-Mobility			Course Code:	R25-EE-HOC-201		
Teaching Scheme (Hrs. / week)			Credits (TH)	Examination Scheme			
Lecture	Practical	Tutorial		CCE	ESE	TW	PR
3	-	-	3	40	60	-	-

Course Description: This course introduces students to the fundamental concepts, technologies, components, and applications of electric mobility. The course covers the evolution of electric vehicles, vehicle configurations, vehicle dynamics, electric motors and drives, batteries and battery management systems, charging infrastructure, power electronics, energy management, and emerging e-mobility technologies. Students will develop a system-level understanding of how electrical, electronic, mechanical, and energy-storage components interact to provide efficient and sustainable transportation.

Course Relevance: The transition from conventional vehicles to electric mobility is an important part of sustainable transportation and energy management. Understanding e-mobility enables students to appreciate the role of electric vehicles in reducing fossil-fuel consumption, emissions, and dependence on conventional energy sources. The course provides interdisciplinary knowledge useful for applications in automobile engineering, electrical engineering, electronics, renewable energy, battery technology, charging infrastructure, and smart transportation systems.

Prerequisite:

1. Basic knowledge of Physics and Mathematics.
2. Basic understanding of electrical circuits, electrical machines, and power electronics.
3. Basic knowledge of automobile systems and energy conversion.

Bridge Content:

- Basic electrical quantities and DC/AC circuits.
- Fundamentals of electric motors.
- Basic concepts of batteries and energy storage.

Course Objectives:

1. **To explain** the fundamentals, evolution, classifications, and architecture of electric and hybrid vehicles.
2. **To analyse** vehicle dynamics, traction requirements, power and energy requirements of electric vehicles.
3. **To describe** electric motors, power electronic converters, batteries, and battery management systems used in e-mobility.
4. **To explain** EV charging systems, charging standards, charging infrastructure, grid interaction.
5. **To evaluate** the environmental, economic, safety, and future aspects of electric mobility and emerging sustainable transportation technologies.

Course Outcomes: After learning the course, students will be able to:

CO	Course Outcome	Bloom's Level
CO1	EXPLAIN the architecture, classification, and operating principles of electric and hybrid vehicles.	L2
CO2	ANALYZE vehicle dynamics, traction requirements, and energy consumption of electric vehicles.	L4
CO3	DESCRIBE electric propulsion systems, motors, power converters, batteries, and battery management systems.	L2
CO4	EXPLAIN EV charging technologies, charging infrastructure, communication, and grid integration.	L2
CO5	EVALUATE the sustainability, economics, safety, and emerging trends of e-mobility systems.	L5

Course Contents			
Unit 1	Fundamentals of E-Mobility and Electric Vehicles	Weeks 1-2	CO1
Introduction to E-Mobility, Concept of mobility and e-mobility. Need for sustainable transportation, Evolution and history of electric vehicles, Advantages and limitations of electric mobility, Environmental and social significance of EVs, Classification of Electric Vehicles, Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), EV Architecture, Basic EV block diagram, Energy flow in EVs, Vehicle powertrain, Hybrid Electric Vehicle Architecture.			
Exemplars / Practical Applications and usage: ● Electric two-wheelers ● Electric cars ● Comparison of BEV, HEV and PHEV.			
Unit 2	Vehicle Dynamics and Electric Propulsion	Week 3	CO2
Fundamentals of Vehicle Dynamics, Forces acting on a moving vehicle, Rolling resistance, Vehicle Performance, Tractive effort, Torque and power requirements, Electric Propulsion, Concept of electric propulsion, Characteristics of EV propulsion systems, Electric Drive Systems, Single motor drive, Dual motor drive, In-wheel motor drive.			
Exemplars / Practical Applications and usage: ● Calculation of traction power for an EV ● Regenerative braking in electric cars ● Comparison of different EV drive configurations.			
Unit 3	EV Motors, Power Electronics and Energy Storage	Weeks 4-5	CO3
Electric Motors for EVs, Requirements of EV motors, DC motor, Induction motor, Power Electronics in EVs, Role of power electronics in electric vehicles, DC-DC converters, Buck and boost converters, EV Batteries, Battery terminology: Cell, module and pack, Voltage, capacity and energy, State of Charge (SOC), State of Health (SOH), Battery Technologies, Nickel-metal hydride batteries, Emerging battery technologies, Battery Management System, Need for BMS.			
Exemplars / Practical Applications and usage: ● Selection of motor for an electric two-wheeler ● Comparison of lithium-ion and LFP batteries ● EV inverter and motor controller.			
Unit 4	EV Charging Infrastructure and Grid Integration	Week 6	CO4
EV Charging Fundamentals, Need for EV charging infrastructure, EV Chargers, On-board charger, Off-board charger, Charging Standards and Communication, EV Supply Equipment (EVSE), Charging connectors, Advanced Charging Technologies, Battery swapping, Wireless charging, EV and Power Grid, Impact of EV charging on the grid, Peak demand, Load management.			
Exemplars / Practical Applications and usage: ● Design of a basic EV charging station ● Home charging system ● Solar PV-based EV charging ● Battery swapping station			
Unit 5	Sustainability, Safety, Economics and Future of E-Mobility	Weeks 7-8	CO5

Environmental Aspects, EV emissions, Life-cycle emissions, Economics of E-Mobility, Initial cost of EV, Operating cost, Maintenance cost, EV Safety, Electrical safety, Battery safety, Indian E-Mobility Ecosystem, EV adoption in India, Charging infrastructure, Battery manufacturing Future Trends, Autonomous electric vehicles, Connected EVs, Smart mobility.

Exemplars / Practical Applications and usage:

- EV battery recycling
- EV safety case study
- Smart and connected electric vehicles
- Future e-mobility ecosystem.

Textbooks:

1. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press.
3. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley.
4. Chris Mi, M. Abul Masrur and David Wenzhong Gao, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley.

Reference Books:

1. Ali Emadi, *Handbook of Automotive Power Electronics and Motor Drives*, CRC Press.
2. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
3. John G. Hayes and G. Abas Goodarzi, *Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles*, Wiley.
4. Mehrdad Ehsani et al., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press.

MOOCs Links and additional reading material:

[SWAYAM/NPTEL – Fundamentals of Electric Vehicles: Technology & Economics](#)
[SWAYAM/NPTEL – Electric Vehicles – Part 1](#)
[NPTEL – Electric Vehicle: Its Components, Charging Infrastructure and Grid Integration Solution](#)
[SWAYAM/NPTEL – Charging Infrastructure](#)

Strength of CO-PO-PSO Mapping														
CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	-	1	-	-	1	2	2	2
CO2	3	3	2	2	-	2	-	1	-	-	2	2	3	2
CO3	3	3	3	2	3	2	-	1	2	-	2	3	3	2
CO4	3	3	3	2	3	3	-	2	2	-	2	3	3	3
CO5	2	2	3	2	2	3	-	2	2	-	3	2	3	3
Avg.	2.8	2.6	2.6	1.8	2.5	2.4	-	1.4	2	-	2.0	2.4	2.8	2.4

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Assessment Pattern							
a) Continuous Comprehensive Evaluation (CCE) – 40 Marks							
The Continuous Comprehensive Evaluation shall be carried out by the Department based on the student's performance throughout the duration of the SWAYAM-NPTEL course. - Performance in NPTEL Weekly Assignments: 30 Marks - Course Progress and Participation (completion of video lectures, timely submission of weekly assignments, and periodic progress monitored by the Faculty Mentor): 10 Marks							
b) End Semester Evaluation (ESE) – 60 Marks							
- Students shall register for and appear in the SWAYAM-NPTEL Proctored Certification Examination. - The marks obtained in the NPTEL Proctored Examination shall be converted proportionally to 60 marks using the following formula: - Students who successfully obtain the NPTEL certificate shall have the converted score considered as the End Semester Evaluation (ESE) marks. - Students who fail to obtain the NPTEL certificate, fail to appear for the NPTEL certification examination, or fail the certification examination shall appear for the Institute End Semester Examination conducted by the College. - If a student appears for both the SWAYAM-NPTEL Certification Examination and the Institute End Semester Examination, the higher of the two ESE scores shall be considered for the award of the final grade. - The decision of the Department regarding verification of NPTEL scores and award of marks shall be final and binding.							
BT Level	CCE						ESE
	CT1	CT2	Assignments	Course Project	Field Activity / Case Study	Quiz / presentation etc.	
L1	-	-	✓	-	-	-	✓
L2	-	-	✓	-	-	-	✓
L3	-	-	✓	-	-	-	✓
L4	-	-	✓	-	-	-	✓
L5	-	-	-	-	-	-	✓
L6	-	-	-	-	-	-	-

This course serves as a prerequisite for / maps with the following future courses: The course provides a foundation for advanced study in Electric Vehicles, Battery Technology, Electric Powertrains, Charging Infrastructure, Energy Management, Vehicle Control Systems, and Sustainable Transportation Systems.

Job Mapping:

- EV Design Engineer
- EV System Engineer
- Battery Engineer
- Battery Management System Engineer
- EV Charging Engineer
- Power Electronics Engineer
- Electric Motor/Drive Engineer
- EV Testing Engineer



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Program:		S. Y. B. Tech (Electrical Engineering)		Semester:		IV	
Course:		Battery Management System		Course Code:		R25-EE-HOC-202	
Teaching Scheme (Hrs. / week)			Credits (TH)	Examination Scheme			
Lecture	Practical	Tutorial		CCE	ESE	TW	PR
3	-	-	3	40	60	-	-
Course Description: This course covers the fundamentals of battery management—including cell chemistry, thermal control, and protection circuits—to help students understand how electronics, software, and hardware integrate within modern electric vehicle energy systems. Course Relevance: Understanding battery management systems enables students to develop green energy storage solutions and collaborate across industries like automotive, aerospace, smart grids, and IoT.							
Prerequisite: ● Basic Physics for understanding energy systems, electrical circuits, and heat transfer. ● Basic Mathematics for state estimation, matrix operations, and solving system dynamics equations. ● Fundamental understanding of basic electrical components, sensors, and basic microcontrollers.							
Bridge Content: ● Overview of electrochemical storage devices and battery parameters (Capacity, C-rate, DOD, Energy Density). ● Essentials of microcontrollers, analog-to-digital converters (ADC), and communication buses (CAN, I2C).							
Course Objectives: 1. To develop an understanding of battery parameters, hardware architecture, and essential sensing circuits in a Battery Management System. 2. To enable students to comprehend the principles of cell balancing and state estimation techniques (State of Charge and State of Health). 3. To equip students with fundamental knowledge of battery thermal management systems (BTMS) and cooling architectures. 4. To introduce safety protocols, fault detection mechanisms, protection circuits, and communication protocols used in BMS. 5. To explore testing standards, industry integration challenges, and emerging trends in battery management technology.							
Course Outcomes: After learning the course, students will be able to:							
CO	Course Outcome					Bloom's Level	
CO1	EXPLAIN the functional architecture, sensing measurements, and parameter monitoring of battery management systems.					2	
CO2	DESCRIBE cell balancing techniques and state estimation methods (SOC, SOH, and SOP) in battery packs.					2	
CO3	DEMONSTRATE an understanding of thermal management strategies and cooling systems for battery packs.					2	
CO4	UNDERSTAND protection schemes, fault diagnosis, pre-charge operations, and hardware isolation in BMS.					2	
CO5	IDENTIFY communication protocols (CAN, LIN), battery testing standards, and emerging trends in cloud-based BMS.					2	

Course Contents			
Unit 1	Fundamentals of BMS and Data Acquisition	Weeks 1-2	CO1
Introduction to Battery Management Systems (BMS); Role and functional blocks of BMS; Sensing requirements: Voltage, Current, Temperature measurement, and Isolation sensing; Analog-to-Digital Conversion (ADC) techniques; Sensor selection and signal conditioning.			
Exemplars / Practical Applications and usage: ● Electric two-wheelers ● Drone battery units, power tools, ● Automotive sensors, data loggers.			
Unit 2	Cell Balancing and State Estimation	Week 3	CO2
Need for cell balancing; Passive balancing vs. Active balancing techniques; State of Charge (SOC) estimation methods: Coulomb Counting, Open Circuit Voltage (OCV), Extended Kalman Filter (EKF); State of Health (SOH) and State of Power (SOP) monitoring.			
Exemplars / Practical Applications and usage: ● Passenger EV battery packs ● Solar energy storage systems ● Laptop batteries, grid energy storage modules.			
Unit 3	Battery Thermal Management Systems (BTMS)	Weeks 4-5	CO3
Heat generation mechanisms in lithium-ion cells; Importance of thermal management; Active and Passive cooling strategies; Air cooling, Liquid cooling, Phase Change Materials (PCM), and direct immersion cooling; Thermal runaway prevention.			
Exemplars / Practical Applications and usage: ● High-performance EV battery packs (Tesla, Tata Motors), ● Electric bus fast-charging packs ● Tropical climate EV designs.			
Unit 4	BMS Protection and Safety Hardware	Week 6	CO4
Undesirable operating conditions: Over-voltage, Under-voltage, Over-current, Short-circuit, Thermal runaway; Protection circuit design, Contactors, Pre-charge circuits; High-voltage interlock loop (HVIL); Insulation Monitoring Devices (IMD).			
Exemplars / Practical Applications and usage: ● High-voltage electric vehicle powertrains ● Industrial energy storage systems ● Medical equipment power packs.			
Unit 5	Communication Protocols, Testing, and Future Trends	Weeks 7-8	CO5
On-board communication networks: Controller Area Network (CAN), Local Interconnect Network (LIN); Hardware-in-the-Loop (HIL) testing; UN 38.3, AIS 156 testing standards; Cloud-connected smart BMS, AI-driven predictive maintenance.			
Exemplars / Practical Applications and usage: ● Telematics systems in modern Evs ● IoT-enabled battery swapping stations ● Fleet management analytics. Smart and connected electric vehicles			

- Future e-mobility ecosystem.

Textbooks:

1. Gregory L. Plett, *Battery Management Systems, Volume I: Battery Modeling*, Artech House.
2. Gregory L. Plett, *Battery Management Systems, Volume II: Equivalent-Circuit Methods*, Artech House.
3. Davide Andrea, *Battery Management Systems for Large Lithium-Ion Battery Packs*, Artech House.

Reference Books:

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L., *Battery Management Systems: Design by Modelling*, Springer.
2. Christopher D. Rahn and Chao-Yang Wang, *Battery Systems Engineering*, Wiley.
3. Rui Xiong, *Battery Management Algorithm for Electric Vehicles*, Springer.
4. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, Wiley.

MOOCs Links and additional reading material:

https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_ee112
https://www.nptel.ac.in/courses/108107002?utm_source=chatgpt.com
https://onlinecourses.nptel.ac.in/noc23_ee01/preview?utm_source=chatgpt.com
https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ee01

Strength of CO-PO-PSO Mapping

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CO2	3	2	2	2	2	1	1	-	1	-	-	2	2	1
CO3	3	3	2	2	2	2	2	-	1	-	-	3	2	1
CO4	2	2	2	1	2	2	1	1	1	-	-	2	1	1
CO5	2	1	1	1	3	1	2	-	1	1	1	2	2	2
Avg.	2.4	2	1.6	1.4	2.2	1.4	1.4	1	1	1	1	2.2	1.6	1.2


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L2	-	-	✓	-	-	-	✓
L3	-	-	-	-	-	-	-
L4	-	-	-	-	-	-	-
L5	-	-	-	-	-	-	-
L6	-	-	-	-	-	-	-

This course serves as a prerequisite for / maps with the following future courses: The course provides a foundation for advanced study in Electric Vehicle Powertrain Design Hybrid Electric Vehicle Systems, Energy Storage Systems and Smart Grids

Job Mapping:

- BMS Hardware Design Engineer
- EV Battery System Integration Engineer
- Thermal Management Engineer (EVs)
- Validation and Testing Engineer - Battery Systems



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