

Government College of Engineering, Karad**Second Year (Sem – III) B. Tech. Electrical****IMI3311 Foundation of EV and Hybrid Vehicle**

Teaching Scheme		Examination Scheme	
Lectures	02 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	02	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite: Basics of Electrical and Electronics.**Course Outcomes (CO):** Students will be able to

CO1	Explain the fundamental concepts, principals and configuration of electric and hybrid electric vehicles
CO2	Identify the various electrical and electronics components for advanced EV
CO3	Discuss hybridization of automobile.
CO4	Illustrate the electric drive-trains characteristics.

Course Contents		CO	Hours
Unit 1	Introduction to EV: <ul style="list-style-type: none"> Current demand in EV industry and opportunities of skilled EV engineers, History and evolution of electric vehicles, Components of an electric vehicle. 	CO1	(04)
Unit 2	Electrical Engineering for EV: <ul style="list-style-type: none"> EV classification and their electrification levels Battery technology, Motor and controller systems, EV numerical calculation EV charging infrastructure. 	CO1	(04)
Unit 3	Advanced Electric Vehicles: <ul style="list-style-type: none"> Electrical Requirement, Power Distribution Specifications, Electronic Component System, EV Standard Specifications Selection of Electrical and Electronic Components. 	CO2	(04)
Unit 4	Hybridization of the Automobile: <ul style="list-style-type: none"> Challenges and Key Technology of HEVs. Basics of Hybrid Electric Vehicle (HEV) Basics of Plug-in Hybrid Electric Vehicles(PHEV) Basics of Fuel Cell Vehicles (FCVs). Vehicle to Grid technology 	CO3	(04)
Unit 5	Hybrid Electric Vehicles: <ul style="list-style-type: none"> HEVs Fundamentals, Vehicle performance, Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples Operation of HEVs 	CO3	(04)
Unit 6	Hybrid Electric Drive-trains: <ul style="list-style-type: none"> Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: <ul style="list-style-type: none"> Basic concept of electric traction, 	CO4	(04)

	<ul style="list-style-type: none"> • introduction to various electric drive-train topologies, • power flow control in electric drive-train topologies, • fuel efficiency analysis. 		
Text Books			
1.	Electric And Hybrid Electric Vehicles Braking Systems & NVH considerations, Author Jurgen R.K., Publisher - Sae International		
Reference Books			
1.	Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2nd Edition, 2003.		
2.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004		
3.	James Larminie, John Lowry, “Electric Vehicle Technology”, Wiley publications, 1st Edition, 2003.		
4.	B D McNicol, D A J Rand, “Power Sources for Electric Vehicles”, Elsevier publications, 1st Edition, 1998		
5.	Seth Leitman, “Build Your Own Electric Vehicle” MC Graw Hill, 1st Edition, 2013		
Useful Links			
1.	https://archive.nptel.ac.in/courses/108/102/108102121/		
2.	https://nptel.ac.in/courses/108/103/108103009/		

Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	-	1	-	-	2	3	-	-	-	-	3	-	-
CO 2	2	-	1	-	-	2	3	-	-	-	-	3	-	-
CO 3	2	-	1	-	-	2	3	-	-	-	-	3	-	-
CO 4	2	2	1	-	-	2	3	-	-	-	-	3	-	-

1: Slight (Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom’s Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	5	5	5
Understand	5	5	20
Apply	5	5	15
Analyse	5	5	20
Evaluate	-	-	-
Create	-	-	-
TOTAL	20	20	60

Government College of Engineering, Karad

Second Year (Sem – IV) B. Tech. Electrical

IMI3412: EV Battery Technology and Powertrain Development

Teaching Scheme		Examination Scheme	
Lectures	02 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	02	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite : Electrostatics and Basic Circuit Laws.

Course Outcomes (CO):Students will be able to

CO1	Analyze the performance of the batteries.
CO2	Discuss and Analyze different energy storage technologies used for hybrid electric vehicles.
CO3	Implement proper drive configuration to electric and hybrid vehicle.
CO4	Visualize the working of an EV powertrain.

Course Contents		CO	Hours
Unit 1	Batteries: Overview of Batteries,Battery Parameters,Lead acid batteries,Lithium ion batteries, Metal air batteries,Battery Charging,Thermal runaway battery management system (BMS),Functionality,SOC/SOH estimation.	CO1	(04)
Unit 2	Energy Storage Systems for EV: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles,Different batteries for EV,Battery Characterization Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control	CO2	(04)
Unit 3	Energy Storage and its analysis: Battery based energy storage and its analysis,Solar Photovoltaic based energy storage system, Fuel Cell based energy storage and its analysis,Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis,Hybridization of different energy storage devices	CO2	(04)
Unit 4	Battery Pack Design and Modeling Battery pack Design,Properties of Batteries,Battery Pack Assembly and Test, Thermal Analysis on Battery Pack, Battery Pack Modeling,The basics of charging technology Types of charging architecture existing globally,CAN communication	CO1	(04)
Unit 5	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles,Configuration and control of DC Motor drives,Configuration and control of Induction Motor drives,configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, Drive system efficiency	CO3	(04)
Unit 6	Electric Vehicle Powertrain: Introduction to EV Powertrain, Special electric traction motors,Various types of regulations and standards set in the CMVR (Central Motor Vehicles Rules - 1989) for selecting and manufacturing various components of an electric vehicle. The rules and regulations need to follow while designing a retrofit powertrain model. Architecture and Components of EV Powertrain, Basics of Carbon footprint of companies and understand how companies utilize carbon credits to reduce their carbon footprint issues	CO4	(04)

Text Books

1.	Handbook on Battery Energy Storage System,ASIAN DEVELOPMENT BANK,2018
2.	Handbook of Automotive Powertrain and Chassis Design

Reference Books

1.	Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2nd Edition, 2003.
2.	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
3.	James Larminie, John Lowry, “Electric Vehicle Technology”, Wiley publications, 1st Edition, 2003.
4.	B D McNicol, D A J Rand, “Power Sources for Electric Vehicles”, Elsevier publications, 1st Edition, 1998

5.	Seth Leitman, "Build Your Own Electric Vehicle" MC Graw Hill, 1st Edition, 2013		
Useful Links			
1.	https://nptel.ac.in/courses/108106170		
2.	https://onlinecourses.swayam2.ac.in/ntr24_ed16/preview		

Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	2	2	-	-	2	3	2	-	-	-	2	-	-
CO 2	2	-	-	-	-	2	3	-	-	-	-	2	-	-
CO 3	2	2	2	-	-	2	3	-	-	-	-	2	-	-
CO 4	2	-	2	-	-	2	3	2	-	-	-	2	-	-

1: Slight(Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom's Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	5	5	5
Understand	5	5	20
Apply	5	5	15
Analyse	5	5	20
Evaluate	-	-	-
Create	-	-	-
TOTAL	20	20	60

Government College of Engineering, Karad

Third Year (Sem – V) B. Tech. Electrical

IMI3513: EV Power Electronics and Embedded System

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	03	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite : Basics of Electronics

Course Outcomes (CO):Students will be able to

CO1	Select proper machine drive for HEVs application.
CO2	Compare different power converters topologies in HEVs
CO3	Develop the basic fundamentals of embedded system , C++ and Linux programming.
CO4	Discuss the sensor characteristics, communication protocol and configuration of the embedded systems

Course Contents		CO	Hours
Unit 1	Electric Machines and Drives in HEVs : Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors. (only functional treatment to be given) .	CO1	(04)
Unit 2	Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, Electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics, Generator and Basics of controlling System in Hybrid Vehicle.		
Unit 3	Power Converter: Introduction, various power electronics converter topologies and its comparisons, Control of convertor operations in EV and HV, EV Charging and Battery System ,Emerging power electronic devices ,PE in renewable energy system, PE in industrial system	CO2	(04)
Unit 4	Introduction to Embedded System: Microcontrollers and microprocessors in EVs, Basics of Embedded System, Embedded C/C++ programming, Idea about Linux, Linux in Embedded System.	CO4	(04)
Unit 5	Sensor Characteristics and communication Protocols: Sensor Principal Characteristics, Sensor-Actuator Integration System. Basic introduction to communication protocols CAN bus, LIN, FlexRay.	CO4	(04)
Unit 6	Configuration of Embedded System: Building of Linux-Embedded System, Application in Embedded Devices, Real-Time Operating Systems (RTOS), RTOS concepts and usage in EVs, Scheduling and task management	CO4	(04)

Handbooks

1.	https://d1.amobbs.com/bbs_upload782111/files_38/ourdev_629261ASTZIF.pdf
2.	Ersan Kabalci ,Power Electronics and Drives Used In Automotive Applications

Reference Books

1.	Power Electronics: Principles and Applications, Joseph Vithayathil, McGraw Hill Publication, 2010
2.	Power Electronics, Cyril W. Lander, 3rd Edition McGraw Hill publication
3.	Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010
4.	L. Ashok Kumar, S. Albert Alexander, “Power Converters for Electric Vehicles”, CRC Press, Taylor & Francis Group, 2021
5.	Automotive Industry Standards, India, 2015-2016

Useful Links

1.	https://nptel.ac.in/courses/108/101/108101038/ (Prof. B. G. Fernandes)
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2.	https://nptel.ac.in/courses/108/102/108102145/ (Prof. G. Bhuvaneshwari)
3.	https://onlinecourses.swayam2.ac.in/ntr24_ed16/preview

Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	1	1	-	-	1	-	-	-	-	-	2	-	-
CO 2	2	1	2	-	-	1	-	-	-	-	-	2	-	-
CO 3	2	2	2	-	3	1	-	-	-	-	2	2	-	-
CO 4	2	2	2	-	3	1	-	-	-	-	2	2	-	-

1: Slight(Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom's Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	-	-	-
Understand	5	5	10
Apply	5	5	20
Analyse	5	5	25
Evaluate	5	5	5
Create	-	-	-
TOTAL	20	20	60

Task III									
ISE									

Government College of Engineering, Karad

Third Year (Sem – VI) B. Tech. Electrical

IMI3615: EV Charging Infrastructure, Vehicle Testing and Homologation

Teaching Scheme		Examination Scheme	
Lectures	02 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	02	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite : Basics of Power Electronics Converters.

Course Outcomes (CO):Students will be able to

CO1	Discuss the electric vehicle market, opportunities and challenges
CO2	Illustrate different EV development methods and unit economics
CO3	Describe the EV charging technologies, standards and protocols.
CO4	Execute site selection and planning infrastructure design

	Course Contents	CO	Hours
Unit 1	Fundamentals of EV Management: Introduction to EV Market, EV Design Procedure and ICE Model, EV Management, EV Homologation and Testing.	CO1	(04)
Unit 2	Charger Manufacturing: FAME India and Manufacturing Guidelines, EV Certification Process, EV Charging, Electric Vehicle and Retrofitting, EV Categories and Proposed Chargers.	CO1	(04)
Unit 3	Product Development Plan: Segment Selection, Product Design Plan, Product Validation Plan, Vehicle Dynamics Selection, Product Design Validation, Product Selection Plan.	CO2	(04)
Unit 4	Development Methods: Product Development Methods, Product Development Plans, Unit Economics, Design feasibility, Design for Manufacturing.	CO2	(04)
Unit 5	EV Charging Technology: Overview, Charging Standards.	CO3	(04)
Unit 6	Charging Infrastructure and Site Selection: EV Charging Infrastructure Design, Site Selection and Planning, Safety and Regularities.	CO4	(04)

Handbook

1.	https://www.niti.gov.in/sites/default/files/2023-02/EV_Handbook_Final_14Oct.pdf
2.	https://sarepenergy.net/wp-content/uploads/2023/07/EV-Technican-Handbook-SAREP.pdf

Reference Books

1.	Electric And Hybrid Vehicles Design Fundamentals, Author Husain Iqbal.
2.	Modern Electric, Hybrid Electric and Fuel Cell Vehicles ,Fundamentals Theory and Design Author Ehsani M.,Gao Yimin , Emadia A. Crc Press Newyork.

Useful Links

1.	https://onlinecourses.nptel.ac.in/noc20_ee99/preview
2.	https://nptel.ac.in/courses/108/103/108103009/
3.	https://onlinecourses.swayam2.ac.in/ntr24_ed54/preview

Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1	-	-	-	-	-	2	-	-	-	3	2	-	2
CO 2	1	-	1	-	-	-	2	-	-	-	3	2	1	-
CO 3	1	2	2	-	-	2	3	-	-	-	-	2	2	-
CO 4	1	2	2	2	-	3	3	2	-	-	2	2	2	-

1: Slight(Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom's Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	-	-	-
Understand	5	5	05
Apply	5	5	20
Analyse	5	5	20
Evaluate	5	5	15
Create	-	-	-
TOTAL	20	20	60

Government College of Engineering, Karad

Final Year (Sem – VII) B. Tech. Electrical

IMI3716: EV Vehicle Design and Analysis

Teaching Scheme		Examination Scheme	
Lectures	02 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	02	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite : Semiconductor Devices Knowledge

Course Outcomes (CO):Students will be able to

CO1	Apply the power electronics technique to diagnostics fault
CO2	Explore the knowledge about analog and digital electronics
CO3	Develop the EV architecture with the help of design and simulation parameters.
CO4	Design and modelling the different EV units.

Course Contents		CO	Hours
Unit 1	Analog Electronics: Sensors for EV Applications (Temperature, Pressure, Current, Voltage) Signal Conditioning Circuits (Amplifiers, Filters) Interface Circuits (Analog-to-Digital Converters)	CO2	(04)
Unit 2	Power Electronics: Pulse Width Modulation (PWM) Techniques Current and Voltage Regulation Overcurrent and Overvoltage Protection Fault Detection and Diagnostics.	CO1	(04)
Unit 3	Digital Electronics: Analog-to-Digital Conversion (ADC) Sensor Types and Characteristics (Temperature, Pressure, Acceleration, etc.) Signal Conditioning Circuits Filtering and Noise Reduction Techniques	CO2	(04)
Unit 4	Automotive Components: Power Semiconductors, Trends in Power semiconductors, Bidirectional Converters, Inverters, Interleaving mode in power converters, Passive Components	CO3	(04)
Unit 5	EV Architecture: Motor development and induction motor characteristics, Simulink model to calculate vehicle configuration, Multilevel inverter design and simulation, DC –DC converter, Motor controllers	CO3	(04)
Unit 6	Modelling and Simulation of Electric Vehicles: Modeling and sizing of the traction systems, Modeling and sizing of the storage systems, Modeling of EV battery and BMS, Interaction between the different blocks of the electrical Architecture	CO4	(04)

Handbooks

1.	K. T. Chau ,Electric Vehicle Machines and Drives: Design, Analysis and Application, ISBN: 978-1-118-75252-4, August 2015, Wiley-IEEE Press
2.	Per Enge ,Nick Enge, Stephen Zoepf, "Electric Vehicle Engineering", 1st Edition, McGraw Hill publication 2021
3.	Handbook of Power Electronics in Autonomous and Electric Vehicles

Reference Books

1.	M. S. Tyagi, Introduction to Semiconductor Materials and Devices, John Wiley & Sons Inc.
2.	Michael Shur, Introduction to Electronic Devices, John Wiley & Sons Inc., 2000.
3.	R. T. Howe and C. G. Sodini, Microelectronics: An Integrated Approach, PrenticeHall Inc. 1997.
4.	Jacob Millman, and C.C. Halkias, "Electronic devices and circuits", TMH Publications
5.	Ben G. Streetman, Solid State Electronic Devices, PHI, 5th Ed, 2001

Useful Links

1.	http://web.iitd.ac.in/~shouri/eel201/lectures.php
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2.	http://www.daenotes.com/electronics/digital-electronics
3.	https://onlinecourses.nptel.ac.in/noc24_ee30/preview
4.	https://onlinecourses.nptel.ac.in/noc22_ee53/preview

Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	-	-	-	-	-	1	-	-	-	-	2	-	-
CO 2	2	-	-	-	-	-	1	-	-	-	-	2	-	-
CO 3	2	1	2	1	1	-	1	-	-	-	-	2	-	-
CO 4	2	1	2	1	1	-	1	-	-	-	-	2	-	-

1: Slight(Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom's Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	-	-	-
Understand	5	-	10
Apply	5	5	20
Analyse	5	5	20
Evaluate	5	5	10
Create	-	5	-
TOTAL	20	20	60

Government College of Engineering, Karad**Final Year (Sem – VIII) B. Tech. Electrical****IMI3817:EV PCB Design & Data Analytics**

Teaching Scheme		Examination Scheme	
Lectures	02 Hrs/week	MSE	20
Tutorials	00 Hrs/week	ISE	20
Total Credits	02	ESE	60
		Duration of ESE	02 Hrs 30 Min

Prerequisite : Basics of Analog and Digital Electronics**Course Outcomes (CO):**Students will be able to

CO1	Discuss the basics of PCB Design and its components.
CO2	Organize and execute hierarchical schematics of EV
CO3	Explore ideas about data visualization.
CO4	Analyze data for electric and autonomous vehicles.

Course Contents		CO	Hours
Unit 1	Basics of PCB Design: Overview, Basic Ideas, Different Technologies, Understanding Schematic Capture.	CO1	(04)
Unit 2	Component Working: Symbol and Nets, Creating Hierarchical Schematic, Multi Sheet Design, Generating Netlist and Bill of Material.	CO2	(04)
Unit 3	Design Applications: Design for Analog and Digital Circuits, Design for Power Electronics, Design for Microwave circuits.	CO1	(04)
Unit 4	Data Analytics: Introduction, Data Collection, Preprocessing, Data Collection Techniques in Electric Vehicle.	CO4	(04)
Unit 5	Data Visualization: Introduction to Data Visualization Technique, Data Exploration, Data Exploration for EV.	CO3	(04)
Unit 6	Overview and Application of Data Analysis: Overview of Data Analysis Techniques, Regression Analysis, Clustering, Application in EV Electrical System, Data Analysis Platform for EV System.	CO4	(04)

Handbook

1.	P-CAD PCB User's Guide
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Reference Books

1.	IPC-PCB Design Desk Reference 2022 Edition
2.	PCB Designing E- Learning Book, Sai Kiran

Useful Links

1.	https://resources.pcb.cadence.com/ebooks-white-papers
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Mapping of COs and POs

PO → CO ↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	2	2	3	2	2	-	1	-	-	-	-	2	-	-
CO 2	1	2	2	-	-	-	1	-	-	-	-	2	-	-
CO 3	1	1	1	2	-	-	1	-	-	-	-	2	-	-
CO 4	1	1	1	2	-	-	1	-	-	-	-	2	-	-

1: Slight(Low)

2: Moderate(Medium)

3: Substantial(High)

Assessment Pattern(with revised Bloom's Taxonomy)

Knowledge Level	MSE	ISE	ESE
Remember	-	-	-
Understand	-	-	10
Apply	5	5	20
Analyse	5	5	20
Evaluate	5	5	10
Create	5	5	-
TOTAL	20	20	60