ELECTRIC VEHICLE TECHNOLOGY **Course Code : 315335**

Programme Name/s	**: Electrical Engineering/ Electrical and Electronics Engineering/ Electrical Power System**
Programme Code	**: EE/ EK/ EP**
Semester	**: Fifth**
Course Title	**: ELECTRIC VEHICLE TECHNOLOGY**
Course Code	**: 315335**

I. RATIONALE

The global movement towards sustainable energy has positioned electric vehicle (EV) technology as a crucial field for electrical engineers. This course is designed to provide students with the essential knowledge and skills to understand, test, and work with EV systems. Through a blend of theoretical instruction and hands-on laboratory experiments, students will develop a thorough understanding of EV technology, equipping them for careers in the rapidly expanding electric vehicle industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Test and use different components of EV systems and compliance of policies & preparing for careers in the electric vehicle industry.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify components and subsystems used in electric vehicles.
- CO2 - Select electrical drives for particular EV application.
- CO3 - Test the performance of batteries and energy storage systems used for EV applications.
- CO4 - Apply the concept of converters and charging system in EV.
- CO5 - Implement Indian and state EV policies for EV applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315335	ELECTRIC VEHICLE TECHNOLOGY	EVT	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare electric vehicles and internal combustion engine vehicles on the given points. TLO 1.2 Describe the configuration of given types of EV system. TLO 1.3 Compare given EVs on the basis of given points. TLO 1.4 Describe the function of given EV subsystem.	**Unit - I Basics of Electric Vehicles** 1.1 History and evolution of electric vehicles (EV), need of EV, Electric vehicles and internal combustion engine vehicles: Comparison on the basis of environmental impact, power source, maintenance, gear change, noise level, vibrations level, capital cost, and running cost. 1.2 Electric vehicle architecture, Types of EV: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV). 1.3 Comparison of different electric vehicle types on the basis of Driving Component, Energy Source used, Features, Problems and models available in market. 1.4 Block diagram of EV subsystems: energy source subsystem, propulsion subsystem and auxiliary subsystem.	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Classify Electric Vehicles. TLO 2.2 Interpret the characteristics of the given electric motor(s) used in EV. TLO 2.3 Distinguish between given EV motors on the basis of given points. TLO 2.4 Select given electrical drives for EV applications.	**Unit - II Electric Vehicle Drives** 2.1 Classification of electric drives used in EV: DC Motor drives, AC Motor drives. 2.2 Brushed DC Motor, Brushless DC Motor (BLDC), Permanent Magnet Synchronous Motor (PMSM), Induction Motor (IM), Synchronous Reluctance Motor (SynRM), PM Assisted Synchronous Reluctance Motor, Axial Flux Ironless Permanent Magnet Motor: Salient features, characteristics, advantages, limitations, and usage of different motor types in EV models. 2.3 Comparison of EV motors based on power-weight ratio, torque-speed characteristic, cost of controllers required and cost of motors. 2.4 Physical location of motor in EV, Rating of motors, Connections (Mechanical and Electrical), and Selection criteria of various types of EV motors.	Lecture Using Chalk-Board Presentations Hands-on Flipped Classroom Video Demonstrations
3	TLO 3.1 Describe given terms related to battery parameter. TLO 3.2 Describe the procedure for selection of battery for the given EV. TLO 3.3 Calculate EV battery capacity based on mileage and load. TLO 3.4 Describe the process of given Battery Management System (BMS). TLO 3.5 Compare given type of fuel cells based on given points.	**Unit - III Batteries and Energy Storage Systems** 3.1 Energy storage technology: EV Batteries, Supercapacitors, flywheel energy storage. Battery Parameters: Cell and Battery Voltages, Charge (or Amphour) Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amphour (or Charge) Efficiency, Energy Efficiency, Self-discharge Rates, Battery Geometry, Battery Temperature, Heating and Cooling Needs, Battery Life and Number of Deep Cycles. 3.2 Batteries: Lead-acid, NiMH (Nickel-Metal Hydride), Li-Ion (Lithium-Ion), Ni-Zn (Nickel-Zinc), Ni-Cd (Nickel-Cadmium), Aluminium–Ion batteries (Al–Ion batteries), Aluminium–air batteries (Al–air batteries)- their basic construction components, life time (cycles), efficiency, advantages and disadvantages. Comparison of various batteries. Factors influencing the operation of battery, and selection of battery. Series and Parallel connection of Batteries, Calculation of battery capacity. 3.3 Battery Management Systems (BMS): Need of BMS, Block diagram of BMS, function of each block, Battery Condition Monitoring, “3R” (Reduce, Reuse, Recycle) process for battery. 3.4 Fuel Cell: Difference between fuel cell and batteries, Fuel Cell Terminology: Anode, Cathode, Electrolyte, Catalyst, Reformer, Direct Fuel Cell, Working principle of fuel cell. Types of Fuel Cells used in EVs: Alkaline Fuel Cell (AFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel cell (SOFC), Their comparison on the basis of Electrolyte type, Cell voltage, Operating temperature, System output (kW), Efficiency (%) and Applications.	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Describe the configuration and functions of the given type of converter. TLO 4.2 Describe given type of EV charging method(s). TLO 4.3 Distinguish between given charging systems. TLO 4.4 Describe given type of charging station. TLO 4.5 Calculate charging time based on given data.	**Unit - IV Converters and EV Chargers** 4.1 Introduction to power electronics used in EV, Block diagram of typical EV: Description and Functions of DC to DC Converter, DC to AC Converter, AC to DC Converter (Rectifier) and filters. 4.2 Charging methods: Home charging, Trickle charging, Household AC charging, Public charging (DC Fast charging). 4.3 Charging System: Classification- Wireless, On board and Off board charging, V1G (Uni-directional smart charging), V2B/V2H (Vehicle-to-Building/ Vehicle-to-Home), V2X (Vehicle-to-Everything), V2G (Vehicle-to-Grid, Bi-directional smart charging). 4.4 Charging Stations: Types of charging station, Public charging station: Selection and sizing, components and, single line diagram. Calculation of charging time and concept of battery swapping. Precautions observed while charging.	Lecture Using Chalk-Board Presentations Flipped Classroom Hands-on Video Demonstrations
5	TLO 5.1 State the given points related to NEMMP. TLO 5.2 Compare incentives policies for the given types of electric vehicle .	**Unit - V Electric Vehicle (EV) Policies** 5.1 Goal of EV30@30 campaign. Goals of electric vehicles initiative in India. National Electric Mobility Mission Plan 2020 (NEMMP): Objectives, Steps taken by Indian Government for faster adoption of electric vehicles, Barriers to adoption of electric mobility, E-mobility strategy, NEMMP 2020 Implementation structure. 5.2 Maharashtra Electric Vehicle Policy, 2021: Objectives, Basic demand incentives for electric vehicles, Vehicle segment-wise scrappage incentives, Incentives for charging infrastructure.	Lecture Using Chalk-Board Presentations Hands-on Flipped Classroom Video Demonstrations

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify components of various types of electric vehicle.	1	*Identification of electric vehicle components.	2	CO1
LLO 2.1 Identify various subsystems of electric vehicles.	2	*Identification of subsystems of electric vehicles.	2	CO1
LLO 3.1 Identify the terminals of Permanent Magnet Synchronous Motor. LLO 3.2 Identify the terminals of Three-phase Squirrel cage Induction Motor. LLO 3.3 Identify the terminals of Synchronous Reluctance Motor. LLO 3.4 Identify the terminals of Brushless DC motor.	3	*Identification of terminals of motors used in EVs.	2	CO2
LLO 4.1 Determine and compare the characteristics of given EV motors.	4	*Comparison of characteristics of EV motors.	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 5.1 Measure open circuit voltage of a given battery using multimeter. LLO 5.2 Identify the charged, discharged and dead battery condition. LLO 5.3 Determine Amphour (Ah) capacity of battery.	5	*Testing of EV batteries.	2	CO3
LLO 6.1 Perform Active Lithium-Ion Cell balancing using Plastic Platform Scale.	6	Battery Cell balancing.	2	CO3
LLO 7.1 Design battery pack for specified capacity of EV.	7	*Design of battery for EV.	2	CO3
LLO 8.1 Charge an EV battery using various methods, and record charging times and efficiency.	8	*Charging of EV battery.	2	CO4
LLO 9.1 Develop a charging station layout. LLO 9.2 Select appropriate components of charging station. LLO 9.3 Draw a single-line diagram of a charging station. LLO 9.4 Simulate the charging process of a charging station using any open-source software.	9	Public charging station for EV.	2	CO4
LLO 10.1 Calculate the charging time for different battery capacities using given formulas.	10	*Calculation of charging time of battery.	2	CO4
LLO 11.1 Prepare a report on Indian EV policy. LLO 11.2 Prepare a report on Maharashtra EV Policy, 2021.	11	*Report on EV policy.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Build and test simple DC-DC converters and inverters.
- Prepare any micro project on EVs.
- Test sensors and systems for autonomous EVs and submit report on it.
- Perform sub-system simulations of an electric vehicle using any open-source software.
- Design and simulate an electric vehicle system model using any open source software.

Assignment

- Prepare a report on comparative study of various two-wheeler EVs available in market.
- Prepare a report on setting of Fast DC charging station.
- Prepare a report on EV battery swapping technology.
- Prepare a report on comparative study of various four-wheeler EVs available in market.
- Prepare a report on Internet of Things (IoT)/ Virtual Reality (VR)/ Augmented Reality (AR) related to EV.

- Prepare report on driverless EV car available in the market.
- Prepare a report on the performance analysis of DC-DC converters and inverters in an EV setup.
- Prepare a report on different EV chargers for two wheeler and four wheeler and make comparative study of them which are available in market.
- Prepare a report on Installation of battery charging unit at Residential Places

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Electric Vehicle two-wheeler: Top Speed-23 KM/H, Minimum Range-80 KM/C, Full Charge-4 to 5 HRS, Minimum Motor Power-250 Watts, Wheel Size-12 Inch, Minimum Battery Capacity/Rating-50V / 30Ah.	1,2,3,4
2	3½ Digit Digital Multimeter.	1,2,3,4
3	Brushless DC motor: 1 kW, 3000 rpm, at 3 Nm load torque/ whichever is available.	2
4	Three-phase AC Induction Motor: Max Motor Power: 41hp at 4500rpm, Max Motor Torque: 91Nm at 3000rpm/ whichever is available.	2
5	Permanent Magnet Synchronous Motor: Minimum power and torque/ whichever is available.	2
6	Synchronous Reluctance Motor: Minimum power and torque/ whichever is available.	2
7	Plastic Platform Scale Active Lithium Cell Balancing, Size: A3, Capacity: 80Ah.	3
8	Lithium-Ion E-Bike Battery, 20 Ah, Capacity (Ah).	3,4
9	Nickel-Metal Hydride E-Bike Battery, 20 Ah, Capacity (Ah).	3,4

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Electric Vehicles	CO1	7	2	8	0	10
2	II	Electric Vehicle Drives	CO2	11	0	4	16	20
3	III	Batteries and Energy Storage Systems	CO3	9	2	4	10	16
4	IV	Converters and EV Chargers	CO4	9	2	8	6	16
5	V	Electric Vehicle (EV) Policies	CO5	4	4	4	0	8
Grand Total				**40**	**10**	**28**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests, each worth 30 marks, will be conducted, and the average of the two tests will be considered.
- For formative assessment of laboratory learning 25 marks: Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment. and the average of all practical will be considered.

Summative Assessment (Assessment of Learning)

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	-	-	1	3	2	3			
CO2	3	-	-	3	3	2	3			
CO3	3	2	3	3	3	2	3			
CO4	3	-	3	3	3	2	3			
CO5	1	-	-	-	3	2	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles.	CRC Press, 2019, ISBN 13: 978-0367137465.
2	James Larminie, John Lowry.	Electric Vehicle Technology Explained.	Wiley-Blackwell, 2012, ISBN 13: 978-1119942733
3	Dr. Nitesh Tiwari, Dr. Shekhar Yadav.	Electric Vehicle (Green and Sustainable Transportation).	S.K. Kataria & Sons, 2023, ISBN 13: 987-81-963589-0-7.
4	Ali Emadi, Mehrdad Ehsani, John M. Miller.	Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles.	CRC Press, 2003, ISBN 13: 978-0824747510.
5	Sunil R. Pawar.	Electrical Vehicle Technology: The Future Towards Eco-Friendly Technology.	Notion Press Publication, 2021, ISBN 10:1685545610.

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://youtu.be/2IgZSDDFW-Y?si=Z1tfZO24ljBppzVA	Identification of terminals of BLDC motor.
2	https://www.niti.gov.in/sites/default/files/2023-02/EV_Handbook_Final_14Oct.pdf	Handbook of electric vehicle charging infrastructure implementation.
3	https://heavyindustries.gov.in/sites/default/files/2023-07/NEMMP-2020.pdf	National Electric Mobility Mission Plan 2020.
4	https://www.cleanenergyministerial.org/initiatives-campaigns/electric-vehicles-initiative/	Goal of EV30@30 campaign.
5	https://maitri.mahaonline.gov.in/PDF/EV%20Policy%20GR%202021.pdf	Maharashtra Electric Vehicle Policy, 2021.
6	https://www.mdpi.com/1996-1073/10/8/1217	Electric vehicle review paper.
7	https://archive.nptel.ac.in/courses/108/103/108103009/	NPTEL electric vehicle course literature.
8	https://onlinecourses.nptel.ac.in/noc22_ee53/preview	NPTEL electric vehicle course videos.
9	https://www.mdpi.com/1996-1073/15/3/1241	DC-AC converters for electric vehicle review paper.
10	https://www.niti.gov.in/sites/default/files/2022-05/Battery_swapping_report_09052022.pdf	Battery swapping.

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students