Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Curriculum Structure and Syllabus

of

Honors in

Electric Vehicle Technology

(Course 2020)

Effective from Academic Year 2023-24
(Updated with Minor Changes)

Institute Vision

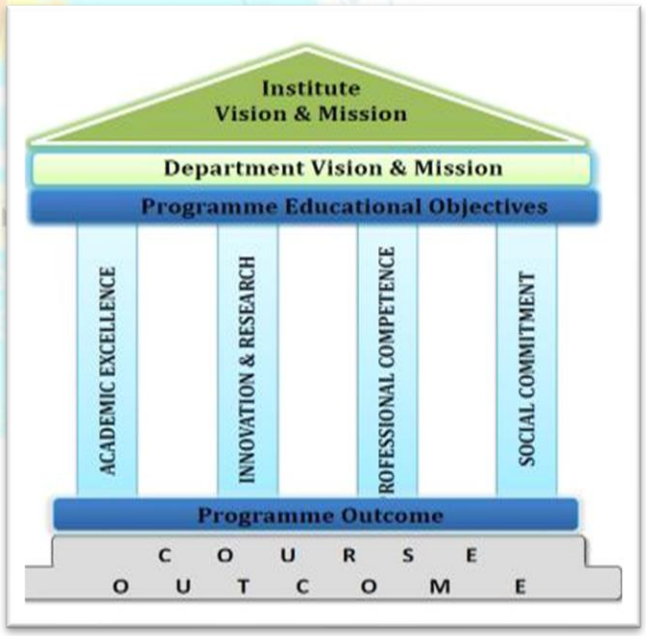
To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value Added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute
2. Imparting right Attitude, Skills, Knowledge for self-sustenance through Quality Education
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with an ability to think and act independently in demanding situations

Quality Policy

We at PCCOE are committed to impart Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders. We shall strive for academic excellence, professional competence and social commitment in fine blend with innovation and research. We shall achieve this by establishing and strengthening state-of-the-art Engineering and Management Institute through continual improvement in effective implementation of Quality Management System.



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Honors in
Electric Vehicle Technology

Preface

Looking at Global Scenario to enhance the employability skills and impart deep knowledge in emerging/ multidisciplinary areas, an additional avenue is provided to passionate learners through the Minors and Honors Degree Scheme in academic structure.

For Honors degree program, student has to earn additional 20 credits in emerging area of one's own domain.

Objectives of Honors Degree

1. To enable students to pursue allied academic interest in contemporary areas.
2. To provide effective yet flexible options for students to achieve basic to intermediate level competence in the contemporary area.
3. To enhance the employability skills with different combinations of competencies and flavors.
4. To provide an academic mechanism for fulfilling demand of specialized areas from industries for higher order skill jobs.
5. To provide a strong foundation to students aiming to pursue research/higher studies in the contemporary field of study.

Electric Vehicle technology

Adopting e-mobility does not only change the way we approach the road but also improves the quality of our lives. The emergence of electric vehicles in recent years introduced a new viable mode of transportation. As a result, the e-mobility ecosystem has become the pillar of the economy, providing millions of jobs worldwide.

Features of Electric vehicle technology course for Electronics Engineers

This course helps to explore in following areas-

1. Components of the Electric vehicles
2. Complexity requirements of Electric vehicles technology
3. State-of-the-Art: analysis of existing Electric vehicles architecture models
4. Various aspects of Electric Vehicles, understand Mobility and its evolutions.

Objectives:

1. To explain the basics of electric vehicle system, their design methodologies, architecture and fundamentals.
2. To analyze various electric motor drives suitable for electric vehicles.
3. To emphasize on the various power electronics devices suitable for electric vehicles.
4. To discuss different energy storage systems used for electric vehicles and their management.
5. To demonstrate different configurations of electric vehicles and its components, sizing of components, design optimization and energy management.
6. To introduce the fundamentals of batteries, Charging and Swapping infrastructure in e-Mobility era.

Outcomes: After completion of this course, students will be able to:

1. Explain the basics of electric vehicles, their design methodologies, architecture and fundamentals.
2. Analyze the use of different electric motor drives in electric vehicles.
3. Analyze the use and suitability of various power electronics devices for electric vehicles.
4. Explain the use of different energy storage devices used for electric vehicles, their technologies and control and select appropriate technology
5. Interpret working of different configurations of electric vehicles and its components, performance analysis and Energy Management strategies in EVs.
6. Appreciate the importance of battery swapping technology in e-mobility domain.

Curriculum Structure

Curriculum structure

Sem-ester	Course Code	Course Name	Teaching Scheme					Evaluation Scheme						
			L	P	T	Hrs.	CR	IE1	IE2	ETE	TW	PR	OR	Total
V	HET5984	Energy storage system for electric Vehicles	4	-	-	4	4	20	30	50	-	-	-	100
	HET5985	Energy storage system for electric Vehicles Lab	-	2	-	2	1	-	-	-	25	-	25	50
VI	HET6984	EV motor drives and controllers for Electric Vehicles	4	-	-	4	4	20	30	50	-	-	-	100
	HET6985	EV motor drives and controllers for Electric Vehicles lab	-	2	-	2	1	-	-	-	25	-	25	50
VII	HET7984	EV system design and architecture	4	-	-	4	4	20	30	50	-	-	-	100
	HET7985	Seminar	-	4		4	2	-	-	-	-		50	50
VIII	HET8982	Project	-	8		8	4	-	-	-	100		50	150
Total			12	16		28	20	-	-	-	-	-	-	600

Abbreviations:

1Lecturehour=1 Credit 2 LabHours=1 Credit 1 TutorialHour=1Credit Abbreviations are: L-Lecture,P-Practical, T-Tutorial, H- Hours, IE- Internal Evaluation, MTE- Mid Term Evaluation, ETE- End Term Evaluation,TW–Teamwork, OR –Oral,CR-Credits

Course Syllabus
Semester-V

Program:	**B.Tech.(E&TC)-Honors In Electric Vehicle Technology**			**Semester:**	**V**		
Course:	**Energy storage system for Electric Vehicles**			**Code:**	HET5984		
Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
4	-	-	4	20	30	50	100

Prior Knowledge of:

1. General background on alternative energy sources and sustainability
2. Electric vehicles configuration Is essential

Course Objectives:

1. To learn fundamentals of energy storage systems for Electric vehicles
2. To understand advanced batteries, super capacitors, and fuel cells for Electric Vehicles
3. To discuss the Hybridization of various energy storage systems such as battery–super capacitors, Battery– fuel cell,and battery–super capacitor–fuel cell
4. To provide the fundamental of battery management systems.

Course Outcomes:

After the completion of the course, the students should be able to:

1. Compare various energy storage devices for Electric vehicles application.
2. Apply the knowledge of energy source technologies for vehicle electrification.
3. Differentiate the battery charging techniques.
4. Understand the fundamentals of battery management systems.
5. Realize the importance of battery recycling technologies.
6. Compare the topology of charging station for Electric Vehicles.

Detailed Syllabus:

Unit	**Description**	**Duration**
1.	**Energy Storage:** Introduction to Energy Storage Requirements in Electric Vehicles. Battery, Fuel Cell, Super Capacitor and Flywheel based energy storage and its analysis, Various aspects in hybridization of different energy storage devices.	11
2.	**Energy Storage Systems:** Batteries-Advanced Lithium Batteries(LMO, NMC, LFP and LTO with their comparative study)and Beyond lithium batteries, Lead-acid battery, High temperature batteries for back-up applications, Double layer and Super capacitors for e-mobility application, Fuel Cells and Hydrogen Storage.	9
3.	**Battery Chargers and Battery Testing Procedures:** Constant current and constant voltage methods, Hybrid methods, Inductive chargers, Battery power testing for various Vehicles, Battery capacity tester, Battery testing for urban and high way driving cycles	11
4.	**Battery Management Systems (BMS):**Concept of Crating, WhandAhrating, SOH, SOC, DOD ratings, active and passive cell balancing, Fundamentals of battery Management systems, block diagram and controls	9
5.	**Battery Recycling Technologies: Technology** and economic aspects of battery recycling, Battery Applications for Stationary and Secondary Use. Introduction of lithium recycling	11
6.	**Electric Vehicles charging station:** System block diagrams, Topologies , Requirement of system, Working principle of EV charging, Types of EV charging systems and its main components of EV chargers.	9
	Total	60

Text Books:

1. James Larminie, John Lowry,ElectricVehicleTechnologyExplained,Wiley,2003
2. D.A.J.Rand,R.Woods,andR.M.Dell,"BatteriesforElectricVehicles,"SocietyofAutomotive Engineers,"Warrendale PA, 2003.
3. Energy Storage by Robert A, Springer Publication
4. Energy Management Handbook, Wayne C. Turner, The Fairmont Press Inc.,5thEdition,Georgia.

Reference Books:

1. G-A.NazriandG.Pistoa,LithiumBatteries,ScienceandTechnology,KluwerAcademicPublisher, 2003.
2. H.A.Kiehne,"Battery Technology Handbook", Marcel Dekker,NYC,2003.
3. JamesLarminieandJohnLowry,"ElectricVehicleTechnologyExplained,"JohnWiley,2003.
4. D.LindenandT.S.Reddy,"HandbookofBatteries,"4th Edition,McGraw-Hill,2011.
5. Energy storage (An ew approach) by Ralph Zito Wiley Publication.
6. NPTEL courses on Energy storage Devices.

Program:	**B.Tech.(E&TC)-Honors In Electric Vehicle Technology**	**Semester: V**
Course: Energy storage system for Electric Vehicles Lab		**Code: HET5985**

Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**TW**	**OR**	**PR**	**Total**
--	02	--	01	25	25	--	50

Prior knowledge of:
Electronic Devices is essential.

Objectives:

1. Develop the student's simulation skill in energy storage device modeling.
2. Analyze parameter for energy storage device.
3. Understand the charging and discharging process of energy storage device.

Outcomes: At the end of Laboratory work, the students will be able to:

1. Analyze charging techniques of energy storage device for Electric Vehicle.
2. Analyze the role of C-rate in charging/discharging a battery.
3. Understand the testing procedure of battery.
4. Design battery pack for EV application.

General Guidelines: Any Eight Experiments is to be performed.

Detailed Syllabus:

Expt. No.	**List of Experiments**
1	Study the basic parameters of battery
2	Measure the charging voltage and current of given battery.
3	Demonstrate any charging technique of lead acid battery/Lithium Ionbattery.
4	Demonstrate the discharging process of battery using various values of C-rate and compare it. Study of ratings of battery for ecycle, 2W EVs, Erickshaws, E-CARsetc
5	Simulate battery model of given battery using any simulation tool.
6	Simulation on charging techniques of battery.
7	Study the process of battery testing and measure the parameters of battery.
8	Study and Demonstration of Battery Temperature Measurement / thermal safety issues(Thermocouple,Thermistoretc)
9	Battery pack design for given EV application (Testing Various series parallel combinations for given application)
10	Case Study: Design,selection,sizingandcomponentsofanydevelopedchargingstation for EV.
11	Visit to any industry/EV charging station/Research laboratory related to battery and EV.

Reference Books:

1. D. Lindenand T.S.Reddy,"Handbook of Batteries,"4th Edition, McGraw-Hill, 2011.
2. D.A.J. Rand, R. Woods, and R.M. Dell, "Batteries for Electric Vehicles, "Society of Automotive Engineers," Warrendale PA, 2003.
3. M.Westbrook,"TheElectricandHybridElectricCar,"SocietyofAutomotiveEngineers,"WarrendalePA, 2001.
4. MATLAB Documents.

Course Syllabus
Semester-VI

Program:	**B. Tech. (E&TC) -Honors In Electric Vehicle Technology**	**Semester:**	**VI**
Course:	**EV motor drives and controllers for Electric Vehicles**	**Code:**	HET 6984

Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**IE1**	**IE2**	**ETE**	**Total**
4	-	-	4	20	30	50	100

Prior Knowledge of: Basics of DC machines, Basics of Electrical Engineering **is essential**

Course Objectives:

1. To understand the components of Electric Vehicle systems.
2. To Study and understand the concepts of various power converters.
3. To learn about DC Motors Drives.
4. To understand speed control techniques of BLDC motor.
5. To learn about Induction motor and SRM motor.
6. Understand the Basic concepts of Electronics Control Unit (ECU) in Electric Vehicles

Course Outcomes:

Students will be able to

1. Explain the basic components of Electric Vehicle systems.
2. Describe the features of power converters for EV.
3. Apply the knowledge of DC motor drives for Electric Vehicle.
4. Apply the knowledge of Brushless DC Motor Drives.
5. Apply the knowledge of AC Motor drives.
6. Illustrate the Basic concepts of Electronics Control Unit (ECU) in Electric Vehicles.

Detailed Syllabus:

Unit	**Description**	**Duration**
1.	**Basics of EV System:** Need**,** Components of EV system : Battery pack, Motor, Controller, Convertor Requirement of EV motors, Motors used in EVs, Selection of operating voltages and power ratings of motors, sensors and actuators.	**9**
2.	**Power Devices and Converters:** Introduction to SCR, MOSFET and IGBTs**,** need of converters, Classification: DC-DC(Buck, Boost, Buck-Boost, Flyback, isolated converters), DC-AC (Single-Phase DC–AC Inverter, Three Phase DC–AC Inverter), AC-DC, AC-AC, unidirectional/ bidirectional, magnetically isolated, selection of converter for EV, Location & power flow, four quadrant operation, input/ output voltage relations for converters	**11**

3.	**DC Motor Drives:** Basics of DC Motor: Construction , working principle of DC Motors- shunt, series, Torque speed characteristics, Comparison of DC motors, Various speed control techniques of DC Motors ,DC series motor drive using DC-DC converters	**10**
4.	**Brush-Less DC motor Drives:** BLDC Machine construction, ,Operation of BLDC Motor, Torque and Rotating Field Production, BLDC Motor Control, BLDC Motor Torque–Speed Characteristics , Typical power, voltage, torque ratings of motors in 2/3/4 wheeler EVS,Sensor -less BLDC Motor Control	**10**
5.	**AC Motor Drive:** Types of AC motors, their Construction and working principle Torque speed characteristics. Speed control techniques for induction motor, inverter fed induction motor drives, Configuration and control of SRM motor.	**10**
6.	**Electronic Control Unit (ECU) in Electric Vehicles:** Introduction to ECU, ECU Components, ECU for EV Powertrain Control, Software in ECU, Data Management.	**10**
	Total	**60**

Text Books:

1. K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CRC Press, Taylor & Francis Group, 2019.
2. C.C Chan, K.TChau: Modern Electric Vehicle Technology, Oxford University Press Inc.,New York 2001 .
3. Rashid M. H.,"Power Electronics Circuits, Devices and Applications",Prentice Hall
4. M D Singh,K B Khanchandani," Power Electronics", Tata McGraw-Hill Education,2017

Reference Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press,2003.
2. JamesLarminie,JohnLowry,ElectricVehicleTechnologyExplained,Wiley,2003.
3. Chang Liang Xia,"Permanent Magnet Brushless DC Motor Drives and Controls" ,Wiley2012.
4. Ramu Krishnan," Permanent Magnet Synchronous and Brushless DC Motor Drives," CRC Press,2009
5. Austin Hughes and Bill Drury," Electric Motors and Drives Fundamentals Types and Applications",Elsevier,2019
6. Ned Mohan, T. Undeland& W. Robbins, "Power Electronics Converters Applications and Design, John Willey & sons, Singapore, 2 nd Edition Oxford University Press, New Delhi, 2005
7. "Applications Notes" by NXP

Program:	**B. Tech. (E&TC) -Honors In Electric Vehicle Technology**	**Semester: VI**
Course:	EV motor drives and controllers for Electric Vehicles Lab	**Code:**HET6985

Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**TW**	**OR**	**PR**	**Total**
--	02	--	01	25	25	--	50

Prior knowledge of: Electric circuits is essential

Objectives:

1. To develop Student's simulation skills in Electric drives and controller
2. To analyze important parameters for Electric drives and controller
3.

Course Outcomes

After completion of this course Students will be able to

1. Analyze the performance of various electronics components used in EV such as SCR, IGBT, MOSFET etc.
2. Demonstrate the speed control techniques of DC and AC Motor Drives.
3. Evaluate the performance of inverters and Choppers.

General Guidelines: Any Eight Experiments is to be performed.

Detailed Syllabus:

Expt.No.	**List of Experiments**
1	Study of sensors and actuators in Electric vehicles.
2	VI characteristics of SCR.
3	VI characteristics of IGBT.
4	VI characteristics of MOSFET.
5	Study of MOSFET based Step up and step down chopper.
6	Chopper fed DC motor drive.
7	Speed control of BLDC motor.
8	Speed control of SRM motor.
9	V/f control of three phase induction motor.
10	Three phase IGBT based PWM inverter control of Induction motor.
11	Industrial Visit to EV industry.

Reference Books:

1. Power Electronics: Circuits, Devices and Applications- M.H Rashid, Pearson Education, PHI 3rdEdition,New Delhi2004
2. M D Singh,K B Khanchandani," Power Electronics", Tata McGraw-Hill Education,2017
3. Fumdamental of Electrical Drives,G.K.Dubey,New Age International Publication
4. MATLAB Documents

Course Syllabus

Semester–VII/VIII

Program:	B. Tech. (E&TC) Honors In Electric Vehicle Technology			Semester:	VII/VIII		
Course:	EV system design and architecture			Code:	HET7984		
Teaching Scheme				Evaluation Scheme			
Lecture	Practical	Tutorial	Credit	IE1	IE2	ETE	Total
4	-	-	4	20	30	50	100

Prior Knowledge of:

Basic Electrical principle and electrical technology is essential.

Course Objectives:

1. To learn the basics of Electric vehicles and its classification
2. To understand the Configurations, Performance and architecture of EV
3. To learn the Modeling and design of Electric vehicles as a system
4. To understand electric components used in electric vehicles and their details.
5. To learn the Energy Storage Systems and energy management strategies for EVs

Course Outcomes:

Students should be able to:

1. Compare Electric Vehicle against the Internal Combustion Engine.
2. Compare the performance of Electric and Plug-in Electric Vehicle.
3. Design EVs as a system.
4. Explain the complete Electric Propulsion unit of Electric vehicles.
5. Apply the knowledge of Energy Storage Systems and energy management strategies for EVs.

Detailed Syllabus:

Unit	Description	Duration
1.	**Introduction to Electric Vehicles:** Main Components of Electric Vehicle, Comparison with Internal Combustion Engine: Technology, Benefits and Challenges, EV classification and their electrification levels. Power and energy requirements of various types of EVs suchas2/3/4 wheelers, trucks and buses etc.	11
2.	**ElectricandPlug-inElectricVehicle:**ConfigurationsofElectricVehicles(EV),PerformanceofEV,Architecturesof EV,Vehiclebatteriesanditsmodelling,BatteryoperatedEV, Plug-in EV	9
3.	**ControlsModelingandDesignforEV:**Systemandsub-systems,ModellinganddesignofEVsas a system, principles of controls engineering for EV.	11
4.	**Electric Propulsion unit:** Introduction to electric components used in electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motordrives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive efficiency.	9
5.	**Energy Storage Systems:** Energy storage systems used, Battery electro-chemistry, battery design and construction, charging and discharging, Importance of power density and energy density, Battery interface vehicle and charging station.	11

6.	**Energy Management Strategies:** Introduction to energy management strategies used inhybridandelectricvehicles,classificationofdifferentenergymanagementstrategies,comparison of different energy management strategies, implementation issues of energy management strategies.	9
	Total	60

Text Books:

1. Iqbal Husain," Electric and Hybrid Vehicles –Design Fundamentals",CRC Press
2. L.Guzzellaand, A.Sciarretta, Vehicle Propulsion Systems: Introduction to modeling and Optimization, Springer2007, Third Edition

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, Sebastian E.Gsay,Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell vehicles-Fundamentals-Theory and Design", CRC Press
2. "Bosch'AutomotiveHandbook",8th Edition

Program:	**B. Tech. (E&TC) -Honors In Electric Vehicle Technology**			**Semester:**	**VII/VIII**
Course:	**Seminar**			**Code:**	HET7985
Teaching Scheme			**Evaluation Scheme**		
Lecture	**Practical**	**Credit**	**IE2**	**TW**	**OR**	**Total**
-	**4**	2			50	50

Prior Knowledge of:--is essential.

Course Objectives:

1. To identify practical learning skills and concepts and learn to communicate it to society.
2. To encourage personal growth of students and development of effective communication skills.

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

1. Get an overview of the current trends and learn them in more details
2. Improve Practice written and oral presentations
3. Learn the research methods used in that specific field

Detailed Guidelines:

1. The student should let the course instructor know in advance the intended topic of the seminar.
2. The length of the seminar should be atmost 30 minutes, including time at the end for questions from the audience.
3. Each seminar should be given by one single student.
4. The intended audience for the seminar are other students at tending the course. Prepare the seminar accordingly.
5. The focus should be on main ideas rather than on technical details
6. The seminar guidelines mentioned in B.Tech (E&TC) structure will be followed for evaluation of performance and certification compliance.

Program:	B.Tech.(E&TC)-Honors In Electric Vehicle Technology			Semester:	VII/VIII
Course:	Project			Code:	HET8982
Teaching Scheme			Evaluation Scheme		
Lecture	Practical	Credit	IE2	TW	OR	Total
-	8	4	-	100	50	150

Prior Knowledge of : Basic electric technology and motors is essential

Course Objectives:

1. To test students' knowledge of course implementation.
2. To make students ready for EV design and analysis..

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

1. Solve real time problems observed in industry.
2. Deal with EV technology, updates, management and analysis motors and drives.

Detailed Guidelines:

1. The students are encouraged to take projects for developing software solutions and hardware platforms using the concept of course taken under the certification.
2. Project should be individual and preferably form Industry.
2.The project guidelines mentioned in B.Tech(E&TC) structure will be followed for evaluation of performance and certification compliance.