Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum/Syllabus

For

Honors in "Electric Vehicles"
Bachelor of Engineering

(Choice Based Credit System)

Honors in Major Disciplines of Mechanical Engineering, Mechanical Engineering (Sandwich), Automobile Engineering and Electrical Engineering - (2019 Course)

Board of Studies – Mechanical and Automobile Engineering

(With Effect from Academic Year 2021-22)

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)
Honors in "Electric Vehicles"

Course Code	Course Name	Teaching Scheme (Hrs/Week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-V														
302031MJ	e-Vehicle Technology	4	-	-	30	70	-	-	-	100	4	-	-	**4**
302032MJ	EV Lab	-	2	-	-	-	50	-	-	50	-	1	-	**1**
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VI														
302033MJ	e-Vehicle System Design	4	-	-	30	70	-	-	-	100	4	-	-	4
	Total	**4**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**4**	**-**	**-**	**4**
Semester-VII														
302034MJ	Modelling and Simulation of EHV	4	-	-	30	70	-	-	-	100	4	-	-	**4**
302035MJ	EV Simulation Lab	-	2	-	-	-	50	-	-	50	-	1	-	**1**
	Total	**4**	**2**	**-**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**1**	**-**	**5**
Semester-VIII														
302036MJ	e-Vehicle Standards, Charging & Safety	4	-	-	30	70	-	-	-	100	4	-	-	4
302037MJ	Seminar	-	-	2	-	-	50	-	-	50	-	-	2	**2**
	Total	**4**	**-**	**2**	**30**	**70**	**50**	**-**	**-**	**150**	**4**	**-**	**2**	**6**

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

1.Rules and Regulations for Honors / Minors Programs

R1.1 It is absolutely not mandatory to any student to opt for Honors or Minors Program. Choice is given to individual students to undertake Honors/Minors programs from the third year engineering (Fifth Semester) to fourth year engineering (Eighth Semester). Honors/Minors programs will be opted from offered programs by SPPU. Once selected he/she will not be permitted to change the Honors/Minors program in forthcoming semesters.

R1.2 The registration for Honors/Minors Programme will lead to gain additional credits to such students. The result of Honors/Minors Program will get reflected in ledgers to be maintained at University only. After the completion of the Honors/Minors program by concerned students, details of credits earned in Honors/Minors program be printed in the mark sheet of eighth semester. For those students, who will not be able to complete the Honors/Minors program, details about the additional credits earned will not get printed.

R1.3 Credits earned through registration and successful completion of the Honors/Minors Programme will **not** be considered for the calculation of SGPA or CGPA.

As per the standard practice, SGPA and CGPA calculations will be done with common base only by considering mandatory credits assigned for the Bachelor programme as per the structure approved by the Academic Council.

R1.4 Students once registered for the programme need to complete all credits assigned for the specific Honors and Minors Programme in the period of 4 years from the Semester-V. Degree with Honors/Minors will be awarded only after the completion of Honors/Minors Programme along with respective UG program degree.

Students may opt to cancel the registration for Honors/Minors within this period of 4 years. After 4 years expire automatically Bachelor's degree will be awarded to such a student provided he/she has earned the credits needed for graduation.

R1.5 Backlog Honors/Minors courses will not contribute to the decision of A.T.K.T.

2. Examination Scheme:

R2.1 Examinations for Honors/Minors Program will be organized at the University Level. Question papers will be common for all students who had opted/registered for the specific Honors/Minors Program. Evaluation of answer books for the Honors/Minors program will be done at the university level.

R.2.2 Additional examination fees as per prevailing rules and regulations will be charged from those students who had registered for Honors/Minors Program to match the expenses for paper setting and the assessment of answer books at the CAP Centre.

Instructions:

- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**

302031MJ: e-Vehicle Technology					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Basics of Electrical and Electronics, Engineering Chemistry, Engineering Systems.

Course Objectives:

To understand the basic technologies used in e-vehicles and the necessary advancements in it.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. UNDERSTAND the basics related to e-vehicle
CO2. CLASSIFY the different hybrid vehicles
CO3. IDENTIFY and EVALUATE the significance of Lithium batteries and BMS
CO4. ILLUSTRATE the issues related to batteries and remedial measures
CO5. EVALUATE the different driving systems for e-vehicles
CO6. DISCOVER and CORRELATE the advancement in e-vehicles

Course Contents

Unit 1	**e-vehicle technology - Introduction**

EV Technology, Significance of e-Vehicle. Types of electric vehicles and it components. Steps in formation of battery pack and its calculation for specific applications. Introduction to suspension system, Mechanical transmission and IoT systems.

Unit 2	**Hybridization in e-vehicles**

Types of hybridization in e-vehicles. Ragone plot, theory and working of Hybridization with IC engine and Battery (with various types), Hybridization of Solar and other non-conventional energy sources with batteries. Current scenarios and its availability in India for different batteries used in e-vehicles.

Unit 3	**Lithium Ion Batteries**

Introduction to lithium batteries and its extensions in different applications. Working principle, advantages and disadvantages. Different chemistries of lithium ion batteries. Evaluation of various battery parameters: State of charge, Depth of discharge, charging rate, etc. current and voltage variation as per different loads. Issues and remedies for battery balancing. Availability of lithium ion batteries and government policies to fulfill the demands of lithium batteries for Indian e-vehicles.

Unit 4	Other Batteries and Battery Management System
Nickel bromide: Working mechanism, advantages, disadvantages, applications; Lead acid batteries: Working mechanism, advantages, disadvantages, applications; Nickel-Metal Hydride Batteries: Working mechanism, advantages, disadvantages, applications; Li Ion supercapacitors: Working mechanism, advantages, disadvantages, applications. Introduction to BMS, BMS sensing and high voltage control, Thermal control and Protection.	
Unit 5	**Introduction to Drive system for e-vehicle**
Introduction to drive systems in EV, Types of motors, selection and size of motors Classification and general characteristics, Motor drives and principle of operation and performance, Mechanical and electrical connections of motors.	
Unit 6	**Advancement in e-vehicles**
Integration of IoT in e-vehicle, Wireless sensor networks need for IoT, Intelligent Transport Systems, Degradation and disposal of batteries, modes of fast and efficient charging, and availability of charging stations as per Indian road conditions. Types of standards. Safety rules and regulations.	

Books and other resources

Text Books:

1. Advances in Battery Technologies for Electric Vehicles, by Bruno Scrosati, Jürgen Garche and Werner Tillmetz, Woodhead Publishing Series in Energy: Number 80.
2. Behaviour of Lithium-Ion Batteries in Electric Vehicles Battery Health, Performance, Safety, and Cost by Gianfranco Pistoia Boryann Liaw.
3. Fundamentals And Applications of Lithium-Ion Batteries in Electric Drive Vehicles Jiuchun Jiang and Caiping Zhang Beijing Jiaotong University, Wiley publications.
4. Electric Motor drives – Modelling, Analysis & Control, R. Krishnan, PHI India, Ltd.

References Books:

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Third Edition, Mehrdad Ehsani Yimin Gao Stefano Longo Kambiz M. Ebrahimi
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi.

302032MJ: EV Lab					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Basics of Electrical and Electronics, Engineering Systems.

Course Objectives:

To have hands-on experience of using basic e-vehicle technologies and their advancements.

Course Outcomes:

On completion of the course, learner will be able to

CO1. RECOGNIZE different e-vehicle technologies

CO2. EVALUATE battery types and capacities

CO3. COMPARE cell balancing

CO4. DEMONSTRATE various power connection types for motor control and battery discharge circuits

CO5. EVALUATE application of specific battery packs

CO6. APPRAISE the practically available e vehicle systems

Term Work

The learner shall complete the following activity as a Term Work; (Any 8)

1. Study of basic components of e-vehicles.
2. Study of basic components of hybrid vehicles.
3. Battery capacity calculations for specific application.
4. Study and verification active and passive cell balancing (using suitable simulation).
5. Battery connections for discharge system (using suitable simulation).
6. Experiment/Simulation for AC-DC, DC-DC, Speed Control using electric motor.
7. Battery pack performance characteristics (To know the variation of time with various battery working parameters).
8. Determination of suitable wire size for specific capacity of motor.
9. Study of different wire harnessing for e-vehicle.
10. Study of Battery Management System.
11. Case study of 2/3/4 wheeler e-vehicle/hybrid vehicle
12. Industry visit

302033MJ: e-Vehicle System Design					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**Theory**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Engineering Mathematics, Mechanics, Solid Mechanics, Material Science and Metallurgy, Kinematics and Dynamics, Mechanisms, Machine design.

Course Objectives:

To understand, design and develop e-vehicles.

Course Outcomes:

On completion of the course the learner will be able to;

CO1. DISCOVER wheel based steering systems
CO2. CLASSIFY and EVALUATE suspension systems.
CO3. USE of tyres and braking systems.
CO4. DESIGN of powertrains and allied transmission systems.
CO5. CATAGORIZE battery pack layouts.
CO6. DEVELOP body frame for e-Vehicles.

Course Contents

Unit 1	**Steering System**

Classification, Topology design of Bicycle, Dicycle, Tricycle and Qudracycle Layouts, 2W Configuration (Bicycle & Dicycle Layouts), 3W Configuration (Delta, Tadpole, Two-wheel-drive with sidecars Layouts), 4W Configuration (2/3/4 Seater), Geometry of Steering System, Classification and Types of steering system and their design.

Unit 2	**Suspension System**

Classification, Topology design and Types of Front and Rear Suspension System, Front Suspension (which includes a Short-long arm with coil spring-over-shock absorber), Rear Suspension (which includes a multi-link and Panhard rod located aluminum beam), Design of Shock Absorbers, Coil Springs and linkages.

Unit 3	**Wheels and Braking System**

Classification, Topology design and Types of wheels/Tyres and Braking Systems, Vehicle and body centre of gravity for movement design of e-Vehicles, Integration of Wheel with traction motor, Braking system, Regenerative Braking.

Unit 4	Powertrain, Differential and Transmission System

Gear-Box Design, Hub Motor Direct Drive Configuration, Centrally Mounted Configuration, Front/Rear wheel coupling to the drive motor.
Drive Layout - One/Two / Four/All-wheel Drive Layout, Transmission System Component design.
Differential Classification and Types (Open, Locked, Spool/Welded, Limited Slip, Torsen, Active, Torque Vectoring)

Unit 5	Battery Compartment

Layout specific Battery Location Selection, Constructional details of Batteries (Battery Pack Structure), Battery Compartment Design for Crashworthiness and Cooling, Vent Management System, Pack Cooling System, Battery life analysis, Battery Performance degradation modelling and analysis.

Unit 6	Roll-cage/Body-Frame

Ergonomics based Roll-cage/Frame Design, Packaging Design, Structural Design aspect of Roll-cage/Body-Frame, Impact/Crash Analysis, Optimization, Vehicle Dynamics

Books and other resources

Text Books:

1. John C. Dixon, J. C., (2009), "Suspension Geometry and Computation", Wiley, NY, ISBN-13: 978-0470510216
2. Matschinsky, M., (1997), "Road Vehicle Suspensions," Wiley, ISBN: 978-1-860-58202-8
3. Guiggiani,M., (2018), "The Science of Vehicle Dynamics: Handling, Braking, and Ride of Road and Race Cars," Springer, ISBN-13 : 978-3319732190
4. Milliken, W. F., (2002), "Chassis Design: Principles and Analysis," SAE International, ISBN-13 : 978-0768008265