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
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 and 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.**

Savitribai Phule Pune University
Honors in "Electric Vehicles"

302031MJ: e-Vehicle Technology					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**TH**	**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.	

Savitribai Phule Pune University
Honors in "Electric Vehicles"

<table>
<tr><th colspan="6">302032MJ: EV Lab</th></tr>
<tr><th colspan="2">Teaching Scheme</th><th colspan="2">Credits</th><th colspan="2">Examination Scheme</th></tr>
<tr><td>Practical</td><td>2 Hrs./Week</td><td>PR</td><td>1</td><td>Term Work</td><td>50 Marks</td></tr>
<tr><td colspan="6">Prerequisites: Basics of Electrical and Electronics, Engineering Systems.</td></tr>
<tr><td colspan="6">Course Objectives:
To have hands-on experience of using basic e-vehicle technologies and their advancements.</td></tr>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">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</td></tr>
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Honors in "Electric Vehicles"

<table>
<tr><th colspan="6">302033MJ: e-Vehicle System Design</th></tr>
<tr><th colspan="2">Teaching Scheme</th><th colspan="2">Credits</th><th colspan="2">Examination Scheme</th></tr>
<tr><td>Theory</td><td>4 Hrs./Week</td><td>TH</td><td>4</td><td>In-Semester</td><td>30 Marks</td></tr>
<tr><td></td><td></td><td></td><td></td><td>End-Semester</td><td>70 Marks</td></tr>
<tr><td colspan="6">Prerequisites: Engineering Mathematics, Mechanics, Solid Mechanics, Material Science and Metallurgy, Kinematics and Dynamics, Mechanisms, Machine design.</td></tr>
<tr><td colspan="6">Course Objectives:
To understand, design and develop e-vehicles.</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">Course Contents</td></tr>
<tr><td>Unit 1</td><td colspan="5">Steering System</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td>Unit 2</td><td colspan="5">Suspension System</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td>Unit 3</td><td colspan="5">Wheels and Braking System</td></tr>
<tr><td colspan="6">Classification, Topology design and Types of wheels/Tyres and Braking Systems, Vehicle and body center of gravity for movement design of e-Vehicles, Integration of Wheel with traction</td></tr>
</table>

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	

Savitribai Phule Pune University
Honors in "Electric Vehicles"

402034MJ: Modeling and Simulation of EHV					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**TH**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Mathematics, Physics, Chemistry, Systems in Mechanical Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Mechanics, Solid Mechanics, Material Science and Metallurgy, Kinematics of Machinery, Computer Aided Engineering, Design of Transmission Systems.

Course Objectives:

1. To understand, model and simulate e-vehicles Motor Drives
2. To understand Energy Storage Systems and effects of working conditions.
3. To analyse the control system, methods and strategies for electric vehicles.
4. To understand electric vehicle configuration for types of electric vehicles.
5. To understand the vehicle dynamics for electric vehicle.
6. To understand Crashworthiness, Manufacturing, Aesthetics and Ergonomics Consideration in electric vehicle.

Course Outcomes:

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

CO1. CLASSIFY and EVALUATE Motor Drives
CO2. MODEL and EVALUATE Energy Storage Systems
CO3. SIMULATE and EVALUATE of ECU, BCU, MCU required for e-Vehicles.
CO4. CATAGORIZE Electric and Hybrid Vehicle Configuration based on Propulsion and Power distribution.
CO5. SIMULATE and DESIGN of Transmission system for e-Vehicles.
CO6. SIMULATE and DESIGN of Frames and Suspension system for e-Vehicles.

Course Contents

Unit 1	**Prime Movers [Electric Motor]**

Motor Drives for EV (using DC Motor Drives, Induction Motor Drives, Permanent Magnet Brushless and Switched Reluctance Motor Drives), Selection of Motor, Structural Configuration of motor layout (single motor, dual motor, in wheel/Hub motor, Planetary-Geared Motors, etc) for EV, Motor Safety and Maintenance, Motor Torque and Power Rating

Unit 2	**Energy Storage Systems [Battery/Cell Pack]**

Types and Packs with respect to Construction, Working, Comparison and Selection (lead-acid, nickel based, lithium-based batteries),Noise Factors, Battery Packs design against Noise and Vibration exposure, Vibration exposure (Mode shapes), Vehicle Dynamics, Battery Pack,

Cooling System and Thermal Management.

Unit 3	Control Units

Introduction-Motor Control System, Modes of Control, Electronic Control Unit [ECU], Battery/Cell Control System, Modes of Control, Battery Control Unit [BCU], Sensor Management and Integration, EV and EHV configuration based on power electronics.
Control Methods and Strategies - Torque Coupling and Speed Coupling, Speed and Torque Controllers, BCU, MCU, Speed control for constant torque, constant HP operation of all electric motors [DC/DC chopper, inverter based V/f Operation (motoring and braking - regenerative braking)], Control methods (Phase Flux Linkage, Phase Inductance, Modulated Signal Injection, Mutually Induced Voltage, Observer -Based).

Unit 4	Electric Vehicle Configuration

Electric Vehicle Configuration, Layouts with respect to Steering, Propulsion and Power distribution - Unicycle, Two-Wheeler (Bicycle, Dicycle, Motorcycle, Scooter, Scooteretts, Mopeds and Underbone), Three-Wheeler, and Four-Wheeler Electric Vehicles, Steering and Propulsion Configuration, Placement of Motors, Battery and Motion Transmission Systems, Drive-Train Topologies.

Unit 5	Frame/Chassis Design

Introduction to body loads (Load cases and load factor, road loads), Vehicle Dynamics, Vehicle Structure/Chassis/Frames, Strength and Stiffness, Frame building Problems, frame components, Front and Rear Suspension Systems, Battery Packs, Understructure Design, FMEA (Failure Mode and Effects Analysis), Vehicle Structure design against Noise and Vibration exposure, Retrofitting and its associated Problems.

Unit 6	Crashworthiness Design

Durability, Fatigue, Crashworthiness, Impact/Crash Analysis/Simulations (Frontal/Rear/Side-Impact/Roll-over), Topology and Topography Optimization, Panel meters and controls on Handle-bar/Dash-board, Body Manufacturing, Aesthetics and Ergonomics Consideration for Stability and Control, Noise Factors & Failure Modes.

Books and other resources

Text Books:

1. Mehrdad Ehsani, Yimin Gao, Sebastein E. Gay, Ali Emadi (2005), "Modern Electric, Hybrid Electric, and Fuel cell vehicles, Fundamentals, Theory, and Design" CRC Press.ISBN 0-8493-3154-4.
2. Chan, C.C. and Chau, K.T., (2001), "Modern Electric Vehicle Technology," Oxford University Press, ISBN: 9780198504160
3. Das, Shuvra, (2021), "Modeling for Hybrid and Electric Vehicles Using Simscape," Springer, ISBN: 9783031003806
4. Du, H., Cao, D., Zhang, H., (2017), "Modeling, Dynamics, and Control of Electrified Vehicles," Woodhead Publishing, ISBN: 9780128127865
5. Scrosati, B., Garche, J., Tillmetz, W., (2015), "Advances in Battery Technologies for Electric Vehicles," Woodhead Publishing, ISBN: 9781782423775

6. Szumanowski, A., (2013), “Hybrid Electric Power Train Engineering and Technology: Modeling, Control, and Simulation,” Hybrid Electric Power Train Engineering and Technology: Modeling, Control, and Simulation, ISBN: 9781466640429.
7. Varga, B. O., Mariasiu, F.,Moldovanu, D., Iclodean, C., (2016),“Electric and Plug-In Hybrid Vehicles: Advanced Simulation Methodologies,” Springer, ISBN: 9783319384443
8. Dincer, I., Halil S. Hamut, H. S., Javani, N., (2017), “Thermal Management of Electric Vehicle Battery Systems,” Wiley, ISBN:9781118900246
9. Wang, S., Fernandez, C., Chunmei, Y., Fan, Y., Wen, C., Stroe, D-I., Chen, Z., (2021), “Battery System Modeling,” Elsevier, ISBN: 9780323904728
10. Vangi, D., (2020), “Vehicle Collision Dynamics: Analysis and Reconstruction,” Butterworth-Heinemann, ISBN: 9780128127506
11. Gokhale, N. S., (2021), “Practical Fatigue and Durability Analysis,” Finite To Infinite, ISBN: 9788195450923

References Books:

1. Plett, G. L., (2015), “Battery Management Systems, Volume I: Battery Modeling,” Artech House, ISBN:9781630810238
2. Plett, G. L., (2020), “Battery Management Systems, Volume II: Equivalent-Circuit Methods,” Artech House, ISBN:9781630810276
3. Davide, A., (2010), “Battery management systems for large lithium battery packs,” Artech House, ISBN: 9781630814823
4. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L., (2002), “Battery management systems: design by modelling,” Springer, ISBN:9789402417876
5. Zhang, X., Mi, C., (2011), “Vehicle Power Management: Modeling, Control and Optimization,” Springer, ISBN: 9780857297358
6. Li, J., (2022), “Modeling and Simulation of Lithium-ion Power Battery Thermal Management,” Springer, ISBN: 978-9811908439
7. Marco, J., Dinh, Q. T., Longo, S., (2020), “Energy Storage and Management for Electric Vehicles,” Mdpi AG, ISBN: 9783039218622
8. Chen, Yong, (2021), “Automotive Transmissions: Design, Theory and Applications,” Springer, ISBN: 9789811567025
9. Gokhale, N. S., Deshpande, S. S., Bedekar, S. V., Thite, A. N., (2020), “Practical Finite Element Analysis,” Finite To Infinite, ISBN: 9788190619509
10. Huang, M., (2002), “Vehicle Crash Mechanics,” CRC Press, ISBN: 9780849301049
11. Prasad, Priya and Belwafa, Jamel E., (2004), “Vehicle Crashworthiness and Occupant Protection,” American Iron and Steel Institute Southfield, Michigan, www.roadsafellc.com
12. Wisch, M., Ott, J., Thomson, R., Léost, Y., (2014), “Recommendations and Guidelines for Battery Crash Safety and Post-Crash Safe Handling,” Swedish National Road and Transport Research Institute.
13. Turner, J. A., Allu, S., Gorti, S., Kalnaus, S., Kumar, A., Lebrun-Grandie, D., Pannala, S., Simunovic, S., Slattery, S., Wang, H., (2015), “Crash Models for Advanced Automotive Batteries: A Review of the Current State of the Art,” Oak Ridge National Laboratory.

14. Kalnaus, S., Wang, H., Kumar, A., Simunovic, S., Allu, S., Gorti, S., Turner, J. A., (2018), “Crash Models for Advanced Automotive Batteries,” Oak Ridge National Laboratory, https://info.ornl.gov/sites/publications/Files/Pub119367.pdf

Savitribai Phule Pune University
Honors in "Electric Vehicles"

402035MJ: EV Simulation Lab					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**PR**	**1**	**Term Work**	**50 Marks**

Prerequisites: Mathematics, Physics, Chemistry, Systems in Mechanical Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Mechanics, Solid Mechanics, Material Science and Metallurgy, Kinematics of Machinery, Computer Aided Engineering, Design of Transmission Systems.

Course Objectives:

To understand the various variation of different working parameters of electric vehicle and its impact of EV components through modeling and analysis using various software.

Course Outcomes:

On completion of the course, learner will be able to

CO1. UNDERSTAND the basics related Simulation and analysis of electric vehicle.
CO2. CLASSIFY the different approaches of battery modeling for single cell and pack.
CO3. IDENTIFY and EVALUATE the significance of hybridization, thermal analysis etc.
CO4. ILLUSTRATE the issues related to batteries and remedial measures.
CO5. EVALUATE the performance of traction motor for performance measures.
CO6. DISCOVER and CORRELATE the advancement in e-vehicles, its testing for different applications.

Guidelines for Laboratory Conduction

Practical related EV analysis preferable to be conducted using Software containing numeric, symbolic, programming and visualization tools (2018 or latest version) with modified driver and drive cycles options. For Structural and thermal analysis any FEA and CFD software (2015 or latest version). Suitable literatures are suggested for further studies. For experimental analysis one needs to make proper electrical connections for optimize set up to evaluate the variation of energy sources w.r.to performance parameters.

Term Work

Student Shall complete minimum 8 practical's from the list given below as a Term Work.

1. Estimation of power rating of traction motor for different gradeability by using software viz. MATLAB/ Simulink.
2. Estimation of power rating of traction motor for maximum vehicle speed by using software viz. MATLAB/ Simulink.
3. Introduction to Battery Module and Simulating a Single Battery Cell Using the MSMD / ECM / NTGK Battery Model.
4. Experimental analysis of hybridization of Battery (li-ion / lead acid) and super-capacitor

for evaluating their performance parameters.

5. Simulation of application oriented electric vehicles for component sizing and positioning and power consumption of electric vehicles and evaluation of performance characteristics for different drive cycles.
6. Simulation of equivalent circuit modeling for electric vehicle 2RC / 3RC battery.
7. Simulation of EV Power Train by using MATLAB/ Simulink.
8. Structural analysis of single stage transmission systems used in e vehicles.
9. Effect of various performance parameters (speed, gradeability, etc.) on total tractive efforts using MATLAB/ Simulink.
10. Sizing of motor power for different operating conditions for two wheeler/ four wheeler application.
11. Modeling and Simulation of Battery crash analysis using suitable FEA software.
12. Structural Analysis& Modeling of battery packs for different applications (2w/3w/4w).
13. Demonstration on the components of electric scooters.

Savitribai Phule Pune University
Honors in "Electric Vehicles"

402036MJ: e-Vehicle Standards, Charging and Safety					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**4 Hrs./Week**	**TH**	**4**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Mathematics, Physics, Chemistry, Systems in Mechanical Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Mechanics, Solid Mechanics, Material Science and Metallurgy, Kinematics of Machinery, Computer Aided Engineering, Design of Transmission Systems

Course Objectives:

- To understand Testing and Evaluation Standards for Electric vehicle.
- To understand about Testing Standards For Hybrid Electric vehicle and Retro-fitment
- To evaluate Battery Charging and Discharging.
- To know Standards for ev batteries and associated testing procedures
- To illustrate Battery failures and its effects on battery components.
- To understand Battery characterizations and safety tests.

Course Outcomes:

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

CO1. UNDERSTAND various standards for Electric vehicles.

CO2. UNDERSTAND about Standards for Hybrid Electric vehicle and its Retro-fitment.

CO3. EVALUATE Battery Charging and Discharging its infrastructural requirements.

CO4. CLASSIFY and EVALUATE Standards for EV batteries and associated testing procedures.

CO5. ILLUSTRATE Battery failures and its effects on battery components.

CO6. UNDERSTAND Battery characterizations and safety tests.

Course Contents

Unit 1	**Testing And Evaluation Standards For Electric vehicle**

Introduction to Automotive Industry Standards (AIS) standards and types. Electric Power Train Vehicles-Construction and Functional Safety Requirements. Protection against electric shock, direct and indirect contact, Water Effects. Test procedures for Electric Power Train Vehicles: Measurement of Electrical Energy Consumption, Fully Charged Rechargeable Energy Storage System. Measuring the Range, Net Power and The Maximum 30 Minute Power, CMVR Type Approval. Electrical safety Requirements of a vehicle, A Rechargeable Electrical Energy Storage System, electric power train.

Unit 2	Testing Standards For Hybrid Electric vehicle and Retro-fitment
Method for Measuring the Electricity Balance of the Battery of OVC and NOVC HEVS. CMVR Type Approval for L Category Hybrid Electric Vehicles: types of test and conditions, Requirements for Regenerative Braking System, Method of Measuring the Electric Range of Vehicles Powered by A Hybrid Electric Power Train. CMVR Type Approval for Hybrid Electric Vehicles of M and N Category: Related terms, types of tests, requirements. Retrofitment standards on Vehicles of L, M and N Category having different weight criteria, types of test and procedures.	
Unit 3	**Battery Charging And Discharging**
Electric Vehicle Battery Charging, Electric Vehicle Battery Fast Charging and discharging, Battery Performance, Testing and Computer-Based Modelling of Electric Vehicle Batteries. Electric Vehicle Charging and grid integration standards, applications, Control architecture in EV charging, communication network. EV integration in the power grid, Role of EV aggregators in EVGI framework, Future development trend of EVGI. EV charging standards for interoperability, charging points.	
Unit 4	**Standards for EV batteries and associated testing procedures**
Introduction: scope and applicability, performance and failure tests, Standards not targeted to EVs. Testing procedures for EV batteries: performance, battery life, battery safety and events. Safety Requirements of Traction Batteries, electrical and mechanical test procedures. Specific Requirements for L, M and N Category Electric Power Train Vehicles, related terms and type of tests. Future trends in battery testing: Insertion of a small nickel particle, Blunt indentation test, Insertion of foreign material during cell fabrication.	
Unit 5	**Battery failures and its effects on battery components.**
Safety Devices, Typical Failure Modes and Mechanism: Thermal Abuse, ramp, Physical Damage, Charge and Discharge Failures, Short Circuit. Safety and Abuse Response for Li-ion Rechargeable Battery. Evaluation Techniques for Batteries and Battery Materials, Battery Chemistries, Electrochemical and Thermal Characterization, Separator Stability, Electrolytes, Gas Generation, Effect of SOC, Age and Cycling, Cell Energy on Thermal Stability. Concept of Calorimetry. Approaches to Improve Safety and Recommendations, Battery Pack and Module Safety.	
Unit 6	**EV infrastructure, Energy, environment and economy**
An Overview of EV Charging Infrastructure, Domestic charging infrastructure, Public charging infrastructure: categories of charging stations, Normal, Occasional, Fast, battery swapping, Move-and-charge zones, Payment systems etc. Standardization and regulations, Training and promotion, Impacts on power system: Harmonic impact, Harmonic compensation, Current demand impact, Current demand minimization. Energy diversification and efficiency, Environment: Transportation pollution, Environment-sound EVs, Economy. Multi-Stakeholder Governance of EV Charging. Assessing Charging Demand And Setting Targets, Location Planning And Land Allocation.	

Books and other resources
Text Books: 1. Web link: https://emobility.araiindia.com/standards. 2. Daniel H. Doughty, Ph.D. Battery Safety Consulting, Inc. Albuquerque, New Mexico, Ahmad A. Pesaran, Ph.D. National Renewable Energy Laboratory (2012). 3. Standards for electric vehicle batteries and associated testing procedures, E. Cabrera CastilloTUM CREATE Ltd, Singapore, (2015) Elsevier Ltd. 4. Sandeep Dhameja, "Electric Vehicle Battery Systems" (2012) Newnes Boston Oxford Johannesburg Melbourne New Delhi. 5. Chan, C.C. and Chau, K.T., (2001), "Modern Electric Vehicle Technology," Oxford University Press, ISBN: 9780198504160 6. H.S. Das, M.M. Rahman, S. Li, C.W. Tan, "Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review" ELSEVIER publication (2019) Renewable and Sustainable Energy Reviews. 7. Handbook of Electric Vehicle Charging Infrastructure Implementation, Version-1, prepared by NITI Aayog, Ministry of Power (MoP), Department of Science and Technology, Bureau of Energy Efficiency, WRI India.
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.

Savitribai Phule Pune University
Honors in "Electric Vehicles"

402037MJ: Seminar					
Teaching Scheme		**Credits**		**Examination Scheme**	
Tutorial	**2 Hrs./Week**	**TUT**	**2**	**Term Work**	**50 Marks**

Prerequisites:

Course Objectives:

1. Identify and compare technical and practical issues related to the area of course specialization.
2. Outline annotated bibliography of research demonstrating scholarly skills.
3. Prepare a well-organized report employing elements of technical writing and critical thinking.
4. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Course Outcomes:

With this seminar report and presentation, the student is expected to learn/achieve the following:

CO1. Establish motivation for any topic of interest and develop a thought process for technical presentation.

CO2. Organize a detailed literature survey and build a document with respect to technical publications.

CO3. Analysis and comprehension of proof-of-concept and related data.

CO4. Effective presentation and improve soft skills with recent technologies.

Guidelines for Seminar Conduction

The evaluation of the seminar report is proposed with the following stages.

Stage-I

In this stage the student is expected to deliver the following:

1. Topic selection (based on the syllabus of this course)
2. Literature review
3. State of the art related to the topic of interest (Simulation/Experimentation/Mathematical modeling/CFD analysis etc.)

Stage-II

1. Problem statement (It must be result oriented solution for specific issues)
2. Methodology
3. Scope and objectives

Stage-III

1. Quantification of results
2. Concluding remarks or summary (must be relevant to the specified objectives)

Stage-IV

1. Final report
2. Final presentation/viva

The group has to make a presentation in front of the faculty of department at the end of semester. During university examination Internal examiner (preferably the guide) and External examiners jointly, evaluate the project work. During the process of monitoring and continuous assessment & evaluation the individual and team performance is to be measured. The project term work shall be evaluated on the basis of reviews. It will be based on synopsis submission Title of the Project Work, abstract, Problem Definition, work done earlier, Objectives of the Project, Methodology of the Project, Application / Significance of the Project as stated above. The final presentation shall be taken in front of external examiner and to be evaluated for 50marks

- 10 marks for presentation for group,
- 20 marks for quality of the project work.
- 20 marks for quality of the project report

Plagiarism check is must, and certificate shall be attached in the report.

Contents of the Seminar report

The contents of the seminar report as mentioned in section-3 are expected to include the following:

- Abstract/Summary
- Introduction: Scope and Methodology
- Literature review: The review should be conducted from at least 10/15reputed / renowned research papers published during last five years.
- Case study
- References

Instructions for seminar report writing

It is important that the procedures listed below be carefully followed by all the students.

1. Prepare two spiral bound copies of your Seminar report.
2. Limit your seminar report to preferably 20 to 25 pages only.
3. Header for e.g. Title of the seminar.
4. The footer For e.g. page numbers
5. Institute Name, Mechanical Engineering and centrally aligned.
6. The report shall be prepared using Latex preferably (default font throughout) with double spacing throughout on A4 page.

Page	Left margin	Right margin	Top margin	Bottom margin
A-4 (8.5×11 inch)	1.5"	1"	1"	1"

7. Section titles should be bold typed in all capital letters and should be left aligned.
8. Sub-Section headings should be aligning at the left, bold and Title Case (the first letter of each word is to be capitalized).
9. Figure No. and Title at bottom with 10 pt; Legends below the title in 10 pt.
10. Please use SI system of units only.
11. References should be either in order as they appear in the report or in alphabetical order by last name of first author.

8. Symbols and notations if any should be included in nomenclature section only.

The report will be made in the following order:

1. Cover page and Front page as per specimen on separate sheet.
2. Certificate from Institute as per specimen on separate sheet.
3. Acknowledgement
4. List of Figures
5. List of Tables
6. Nomenclature
7. Contents
8. All section headings and subheadings should be numbered. For sections use numbers1, 2, 3 ... and for subheadings 1.1, 1.2, etc. and section subheadings 2.1.1, 2.1.2,etc.
9. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference, then indicate source of it. Please follow the following procedure for references.

Reference Books: Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3 rd ed., Oxford University Press, UK, 1996, pp. 110 112.

Papers from Journal or Transactions:

1. Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, ASHRAE Trans, 1991, 97 (1), pp. 90 98.
2. Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, Int. Journal of Refrigeration, 1996, 19 (8), pp.497 505.

Papers from Conference Proceedings:

1. Colbourne, D. and Ritter, T. J., Quantitative assessment of flammable refrigerants in room air conditioners, Proc. of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 40.

Reports, Handbooks etc.

1. United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps, Technical Option Committee, 2002, Assessment - 2002. ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent: Patent no, Country (in parenthesis), date of application, title, year.

Web-links: www.(Site) [Give full length URL].