Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College Affiliated to the University of Mumbai)

Scheme and detailed Syllabus (DJ19)

of

Honours Degree Program

in

Electric Vehicle

Revision: 1 (2022)

With effect from the Academic Year: 2022-2023

Proposed scheme for Honours in Electric Vehicle
(Academic Year 2022-2023)

Sr.	Course Code	Course	Teaching Scheme (hrs.)				Continuous Assessment (A) (marks)			Semester End Assessment (B) (marks)					(A+B)	Total Credits
			Th	P	T	Credits	Th	T/W	Total CA (A)	Th / Cb	O	P	O & P	Total SEA (B)		
Sem V																
1	DJ19MEHN1C1	Fundamentals of Electric Vehicles	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
Sem VI																
2	DJ19MEHN1C2	Electric drives and controls	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
3	DJ19MEHN1L1	Electric Vehicle Laboratory 1		2		1		25	25	--	--	--	25	25	50	**1**
Sem VII																
4	DJ19MEHN1C3	Energy source management	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
5	DJ19MEHN1L2	Electric Vehicle Laboratory 2	--	2	--	1	--	25	25	--	--	--	25	25	50	**1**
Sem VIII																
6	DJ19MEHN1C4	Electric Vehicle System Design	4	--	--	4	25	--	25	75	--	--	--	75	100	**4**
		Total	**16**	**4**	**0**	**18**	**100**	**25**	**125**	**300**	**0**	**0**	**25**	**325**	**500**	**18**

Honors in Electric Vehicles **Semester: V**

Program: Mechanical Engineering

Course: Fundamentals of Electric Vehicles (DJ19MEHN1C1)

Pre-requisite:

1. Basic of electronics and electrical engineering
2. Fundamentals of physics and engineering mechanics

Objectives:

1. To study different automotive components and subsystems
2. To explore the transition of automotive domain from Internal Combustion Engine to electric vehicles

Outcomes: On completion of the course, the learner will be able to:

1 To explain the basic of Electric vehicles and its major parts.
2. To define the functionality and working principles of different types of Automotive Powertrains
3. To illustrate the working of various automotive transmission systems
4. To explain vehicle fundamentals of various subsystem.
5. To illustrate the working of motors and conversions.
6. To identify and illustrate the various hybrid electric powertrains and their different modes of operations

Electric Vehicles (DJ19MEHN1C1)		
Unit	**Description**	**Duration**
1	**Electric Vehicles** History, Basics of Electric Vehicles ,Components of Electric Vehicle, General Layout of EV, EV classification : Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs) Comparison with Internal Combustion Engine: Technology, Advantages & Disadvantages of EV, National Policy for adoption of EVs, Overview of Tesla car.	10
2	**Vehicle Mechanics** History of Vehicle Development, General Configuration of Automobile, Body and Chassis Fundamentals: General Packaging, Types of Structural System, Backbone Construction; Body and Chassis Materials. Automotive Powertrain Mechanical, Suspensions system, Steering System, NVH, Control System Integration and Implementation. Front-Wheel Drive (FWD) Powertrains, Rear-Wheel Drive Powertrains (RWD), Multi-Wheel Drive Powertrains (AWD and 4WD).	10
3	**Transmission Systems** Transmission gears, Manual Transmission (MT), Automatic Transmission (AT), Automated Manual Transmissions (AMT) and Continuously Variable Transmissions (CVT); Manual Transmissions Powertrain Layout and Manual Transmission Structure, Power Flows and Gear Ratios, Manual Transmission Clutch and its structure. Drivetrain and Differential.	10
4	**Vehicle fundamentals** Vehicle resistance, Types: Rolling Resistance, grading resistance, Aerodynamic drag vehicle performance, Calculating The Acceleration Force, maximum speed, Finding The Total Tractive Effort, Torque Required On The Drive Wheel, Transmission: Differential, clutch &gear box, Braking performance.	10

5	**Conversions and motors** Introduction of DC-DC, AC-AC, AC-DC, DC-AC, four-quadrant operation, Driver circuits. Principle and working of DC motor, Characteristics and Types of DC Motors- Overview (Speed torque characteristics) of Permanent Magnet motor, BLDC Motor, Induction motor. Comparison of all motors.	6
6	**Hybrid Powertrain**: Series HEVs, Parallel HEVs, Series–Parallel HEVs, Complex HEVs, Operating Modes, Degree of Hybridization, Comparison of HEVs, Plug-in Hybrid Electric Vehicles (PHEVs) Real Life examples of HEVs, compare and contrast the performance of ICE vehicles, HEVs and EVs.	**6**
	Total	**52**

Books Recommended:

Text books:

1. Vehicle Powertrain Systems by Behrooz Mashadi and David Crolla, Wiley, 2012
2. Automotive Aerodynamics by Joseph Katz, Wiley, 2016
3. Automotive Chassis Engineering, by David C. Barton and John D. Fieldhouse, Springer, 2018
4. Automotive Engineering Powertrain, Chassis System and Vehicle Body Edited by David A. Crolla, Elsevier,2009
5. Automotive Power Transmission Systems by Yi Zhang and Chris Mi, Wiley, 2018
6. Linear Electric Machines, Drives, and MAGLEVs Handbook, by Ion Boldea, CRC Press. 2013
7. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi, CRC Press 2005
8. Electric Vehicle Technology Explained by James Larminie and John Lowry, John Wiley, 2003
9. Electric and Hybrid Vehicles- Design Fundamentals by Iqbal Husain, CRC Press, 2005

Reference Books:

1.Encyclopaedia of Automotive Engineering edited by David Crolla et al, Wiley, 2014
2. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
3. The Automotive Transmission Book by Robert Fischer, Ferit Küçükay, Gunter Jürgens, Rolf Najork, and Burkhard Pollak, Springer, 2015
4. Noise and Vibration Control in Automotive Bodies by Jian Pang, Wiley, 2019

Continuous Assessment (A):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	One Term test (based on 40 % syllabus)	25 each (Avg.25)	1
	Second Term test (next 40 % syllabus) / presentation / assignment / course project / group discussion / any other.		--
Audit course	Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.	--	
Laboratory	Performance in the laboratory and documentation.	--	
Tutorial	Performance in each tutorial & / assignment.	--	
Laboratory &Tutorial	Performance in the laboratory and tutorial.	--	

The final certification and acceptance of term work will be subject to satisfactory performance upon fulfilling minimum passing criteria in the term work / completion of audit course.

Semester End Assessment (B):

Course	Assessment Tools	Marks	Time (hrs.)
Theory / * Computer based	Written paper based on the entire syllabus.	75	3
	* Computer based assessment in the college premises.		
Oral	Questions based on the entire syllabus.	--	--
Practical	Performance of the practical assigned during the examination and the output / results obtained.	--	--
Oral & Practical	Project based courses - Performance of the practical assigned during the examination and the output / results obtained. Based on the practical performed during the examination and on the entire syllabus.	--	--

Honours in Electric Vehicles **Semester: VI**

Program: Mechanical Engineering

Course: Electric Drives and Controls (DJ19MEHN1C2)

Pre-requisite:

1. Basic of Electronics and Electrical Engineering
2. Fundamentals of Physics and Engineering Mechanics

Objectives:

1. To study various EV motors & their Characteristic Curves
2. To study various Electronic devices and Elements of drives
3. To study various EV motor drive topologies and their working principles
4. To understand various sensors in EV
5. To understand the basics requirements of motors and controllers for EV
6. To understand suitability of electric motor & their control

Outcomes: On completion of the course, the learner will be able to:

1. Explain the construction and working principle of various motors used in electric vehicles
2. Describe about the Motor & Drive characteristics & parameters
3. Explain about various EV drive concepts and working mechanism
4. Analyze the requirements of EV motors
5. Evaluate the suitability of electric motor & their control for EV
6. Comprehend the Configurations and Performance of Electric vehicles, their drives and control

Electric Drives and Controls (DJ19MEHN1C2)		
Unit	**Description**	**Duration**
1	**EV Motors and Characteristics:** Requirement of EV motors, Review of motor principles, Motor load dynamics; Specifications of motors, Characteristic Curves of motors; Motion profile : acceleration, steady operation and deceleration profiles; Starting, braking, speed and torque control of motors; Constant-Torque Mode, Constant-Power Mode; Efficiency Map; Design variables of motors (introduction); Classification properties of PM material, Alnico, Ferrites, Rare-Earth PMs	**08**
2	**Basics of power conversion:** Power devices : SCR, Triac, BJT, Mosfet and IGBT. Power Conversion – DC-DC converters, DC-AC Converters and AC-DC Converters used in EV applications; Voltage source inverter, Current source inverter. High power and low power loops. Converter / Inverter Loss calculation.	**06**
3	**Elements of drives:** Encoders, Resolvers, R/D Converters, Hall current sensors and current sampling, Voltage Model Estimator, Current Model Estimator, Closed-loop MRAS observer, Sliding Mode Observer. Modulation schemes**:** Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation, comparison of modulation techniques.	**06**
4	**EV Motors Drive Topologies -1 :** DC motor - Brushed and Brushless DC motors (BLDC); Basics of brushed DC Motor, DC Motor dynamics, Characteristic Curves; DC Motor Control: Single phase uncontrolled rectifiers, half and fully controlled rectifiers, chopper control, open and closed loop control. Current Loop Control, Speed Control Loop. Feedback Linearization; Four quadrant operation; AC Motors: Induction motors (IM), permanent-magnet ac synchronous motor-surface-permanent-magnet (SPM) motors and interior-permanent-magnet (IPM) motors; constructional details and Characteristic Curves;	**12**

	Induction Motor Control: Starting methods and speed control of single-phase induction motors, Variable-Voltage Variable-Frequency Control (VVVF), Field-Oriented Control (FOC), Direct Torque Control (DTC); , Field Weakening Control;	
5	**EV Motors Drive Topologies -2 :** Switched Reluctance Motor (SRM); Basic construction details and working principles of SRM machine, Types of SRM. Characteristic Curves; SRM motor control: Current chopping control (CCC), Torque-Ripple Minimization Control; BLDC Motor: Basic principles of BLDC Motor, motor construction, Types of BLDC motors. Characteristic Curves; BLDC Motor Control*:* Trapezoidal back EMF BLDC motor control, sensored control; PM Synchronous Motor Control: Field-Oriented Control of PMSM, Flux-Weakening Control of PMSM, Position Sensorless Control of PMSM;	**12**
6	**Selection / sizing of EV motors** : Comparison of EV motors; Thermal Management - passive and active cooling; Suitability of each machine in Electric vehicle domain for 2W, 3W, 4 wheeler and large size vehicles. Real life examples/case studies; Review of advancement in EV Motors and Drives.	**08**
	Total	**52**

List of Experiments (Any 8)

Electric Vehicle Laboratory 1 (DJ19MEHN1L1)		
Exp.No.	**Category**	**Experiment Title**
1	Devices	Study of Device Characteristics, linear and switching operations : SCR, Triac, BJT, Mosfet and IGBT. Study of Protection circuits.
2	Embedded Platform	Study of any one Embedded platform (Atmel, STM32, Microchip, TI) for Basic Embedded operations (I/O processing, interrupt processing..)
3		Study of Embedded platform (Atmel, STM32, Microchip, TI) for ADC processing, UART communications.
4		Study of any one Embedded platform (Atmel, STM32, Microchip, TI) for Timer and PWM Generations.
5	Low voltage loop	MOSFET based Step up and step down converter for low voltage EV loops
6	Drive Schemes	Half and full bridge converter and role of control signals for DC motor
7	Motor Control	Demonstrating both Current/Voltage loop control of DC motor
8	Drive Schemes	Study of drive schemes and role of control signals for induction motor
9	Motor Control	Demonstrating Control of Induction motor
10	Drive Schemes	Study of drive schemes and role of control signals for BLDC/PMSM/SRM motor
11	Motor Control	Demonstrating Control of BLDC /PMSM /SRM motor
12	Drive Schemes	Study of drive schemes and role of control signals for three phase induction motor
13	Motor Control	Demonstrating Control of three phase induction motor

Minimum eight experiments from the above suggested list or any other experiment based on syllabus will be included, which would help the learner to apply the concept.

List may be expanded to include Finite Element Method Magnetics (FEMM) modeling by simulating the motor, this helps them simulate and model efficient motors.

Books Recommended:

Text books:

1. Gopal K D, "Fundamentals of Electric Drives", Narosa Publishing House Pvt. Ltd., 2011.
2. Pillai S K, "A first course on Electrical Drives", Wiley Eastern Ltd, Bombay 2011.
3. Ali Elamadi, "Handbook Automotive Power Electronics and Drives", CRC publishers, 2012.
4. Bimal K Bose, "Modern Power Electronics and Drives", Elsevier publishers, Butterworth Hinnemann, 2012.
5. Krishnan R, "Permanent Magnet synchronous and Brushless DC Motor Drives", CRC Publishers, 2010.
6. Austin Hughes, Bill Drury, "Electric Motors and Drives Fundamentals, Types and Applications", Newnes , 5th Edition , 2019
7. Marian Kazmierkowski, Ramu Krishnan, Frede Blaabjerg ,"Control in Power Electronics", Academic Press, 1st Edition - August 20, 2002

Reference Books:

1. Krishnan R, "Switched Reluctance Motor Drives: Modelling, Simulation, Analysis, Design and Applications", CRC Publishers, 2012.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
4. K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019
5. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

Continuous Assessment (A):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	One Term test (based on 40 % syllabus)	25 each (Avg.25)	1
	Second Term test (next 40 % syllabus) / presentation / assignment / course project / group discussion / any other.		As applicable
Audit course	Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.	--	
Laboratory	Performance in the laboratory and documentation.	25	
Tutorial	Performance in each tutorial & / assignment.	--	
Laboratory &Tutorial	Performance in the laboratory and tutorial.	--	

Semester End Assessment (B):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	Written paper based on the entire syllabus.	75	3
Oral	Questions based on the entire syllabus.	--	--
Practical	Performance of the practical assigned during the examination and the output / results obtained.	--	--
Oral & Practical	Project based courses - Performance of the practical assigned during the examination and the output / results obtained. Based on the practical performed during the examination and on the entire syllabus.	25	2

The final certification and acceptance of term work will be subject to satisfactory performance upon fulfilling minimum passing criteria in the term work / completion of audit course.

Honours in Electric Vehicles **Semester: VII**

Program: Mechanical Engineering

Course: Energy Source Management (DJ19MEHN1C3)

Pre-requisite:

1. Basic of electrical engineering
2. Fundamentals energy science

Objectives:

1. To study various energy source and their characteristics.
2. To study and explore the management strategies with optimization techniques used in hybrid and electric vehicles.

Outcomes: On completion of the course, the learner will be able to:

1. To describe battery basics and its different types.
2. To describe battery charging and swapping infrastructure.
3. Illustrate the various types and working principle of fuel cells.
4. To explain energy management strategies with optimization techniques used in hybrid and electric vehicles.
5. To explore technique for energy storage, distribution and grid modernization.

Energy Source Management (DJ19MEHN1C3)		
Unit	**Description**	**Duration**
1	**Overview of Battery Technologies** Types of Battery, Introduction to Electrochemical Battery, Electrochemical Reactions, Battery Parameters: Battery Capacity, Discharge Rate, Charging Rate, SOC, SOD, SOH, DOD, Thermodynamic Voltage, Specific Energy, Specific Power, Energy Efficiency, Battery Technologies (used in Tesla Car), Lead-Acid Battery, Nickel Based Battery, Lithium Battery (Li-ion Li-Polymer), Role in Electric Drive Train, Comparisons, Introduction to Graphene Battery, Proposed Batteries.	12
2	**Battery Charging and Swapping Infrastructure** Introduction to Battery Chargers: On-board chargers and Off-board chargers, Topologies and Standards, Types of Charging Station, Selection and Sizing of Charging Station, Single Line Diagram of Charging Station, Charging Station Placement for Electric Vehicles: A Case Study, Battery Swapping Technology.	10
3	**Fuel Cell** Overview of Key Fuel Cell Technologies – Various Types of Fuel Cells, Materials for Electrodes, Electrolytes and Other Components, Working Mechanisms, Hydrogen Generation and Storage: Limitations, Recent Progress in Fuel Cells, Safety Issues and Cost Expectation and Life Cycle Analysis of Fuel Cells.	7

4	**Energy Grid Modernization** Solar Photovoltaic, Solar Cell, Solar Cells to Modules, Wind Energy, The War of Currents, Solar-DC, Introduction to EV Subsystem, Going Beyond Solar, Wind, Li Ion and Chilled Water Storage, Engineering Considerations and Future Frontiers.	7
5	**Energy Management System** In Vehicle Networks – CAN, Energy Management Strategies: Introduction to Energy Management Strategies with Optimization Techniques used in Hybrid and Electric Vehicles, Classification of Different Energy Management Strategies, Comparision of Different Energy Management Strategies and Implementation Issues of Energy Management Strategies,	8
6	**Energy Storage and Distribution** Electrical energy route – Load curves – Energy Conversion Plants for Base Load, Intermediate Load, Peak Load and Energy Displacement – Energy Storage Plants. Energy Scenario – Global and Indian –Impact of Energy on Economy, Development and Environment, Energy Policies, Energy Conservation Opportunities, Electrical ECOs Energy, Strategy for Future.	8
	Total	**52**

List of Experiments

Electric Vehicle Laboratory 2 (DJ19MEHN1L2)	
Exp.	**Suggested experiments**
1	Study of Battery Compositions, Equations and Equilibrium.
2	Study and Demonstration of Balanced and Unbalanced Charging.
3	Study and Demonstration of SOH.
4	Study and Demonstration of SOD.
5	Study and Demonstration of SOC.
6	Study of Charging Station Topologies.
7	Demonstration of any one Charging Station Topology.

Books Recommended:

Text books:

1. Energy Resource Management, Krupal Singh Jogi (Sarup & Sons).
2. Non-Conventional Energy resources, Dr. B.H. Khan, Tata McGraw Hill.
3. Electrochemical Energy Storage: Physics and Chemistry of Batteries, De Gryuter, Reinhart Job.
4. Batteries: Materials Principles and Characterization Methods, Chen Liao, Chemical Sciences and Engineering Division, Argonne National Laboratory, Lemont, USA.
5. Batteries, Fuel Cells, and related Electrochemistry, U.S. Department of Energy, Washington, D.C. 20585.

Reference Books:

1. Energy Management: W.R. Murphy, G. McKay (Butterworths).
2. Energy Management Principles: C.B. Smith (Pergamon Press).
3. Energy Management and Control System: Vol-I, II – M.C. Macedo (John Willy).
4. Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors, Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, 2015.
5. Amlan Chakrabarti, Energy Engineering and Management, Prentice Hall India, 2011.
6. World Energy Resources: Charles E. Brown, Springer 2002.
7. Fuel Cells and Hydrogen: From Fundamentals to Applied Research, V. Hacker, S. Mitsushima (Eds.), Elsevier, 2018.
8. Energy for a Sustainable World: Jose Goldenberg, Thomas Johansson, A.K.N. Reddy, Robert Williams (Wiley Eastern).

9. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Practice, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi.
10. Solar Energy, S.P. Sukhatme, Tata McGraw Hill.
11. Non-Conventional Energy Sources, G.D. Rai., Khanna Publications.
12. Energy Policy and Planning: B. Bukhootsow.
13. Wind Energy Systems – G.L. Johnson (Prentice Hall, 1985).

Continuous Assessment (A):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	One Term test (based on 40 % syllabus)	25 each (Avg.25)	1
	Second Term test (next 40 % syllabus) / presentation / assignment / course project / group discussion / any other.		as applicable
Audit course	Performance in the assignments / quiz / power point presentation / poster presentation / group project / any other tool.	--	
Laboratory	Performance in the laboratory and documentation.	25	
Tutorial	Performance in each tutorial & / assignment.	--	
Laboratory &Tutorial	Performance in the laboratory and tutorial.	--	

The final certification and acceptance of term work will be subject to satisfactory performance uponfulfilling minimum passing criteria in the term work / completion of audit course.

Semester End Assessment (B):

Course	Assessment Tools	Marks	Time (hrs.)
Theory	Written paper based on the entire syllabus.	75	3
Oral	Questions based on the entire syllabus.	--	--
Practical	Performance of the practical assigned during the examination and the output / results obtained.	--	--
Oral & Practical	Project based courses - Performance of the practical assigned during the examination and the output / results obtained. Based on the practical performed during the examination and on the entire syllabus.	25	2

A minimum of six experiments from the above-suggested list or any other experiment based on syllabus may be included, which would help the learner to apply the concept learnt. A case study or seminar report relevant to the topics may be included, which would help the learner to apply the concept learnt.