SCHEME & SYLLABUS

for

Minor Degree / Specialization Programme

in

Electric Vehicle Technology

Department of Electrical Engineering

Faculty of Engineering & Technology

J. C. Bose University of Science & Technology, YMCA

Faridabad, Haryana

J. C. BOSE UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA FARIDABAD (HARYANA)

VISION

J. C. Bose University of Science and Technology, YMCA, Faridabad aspires to be a nationally and internationally acclaimed leader in technical and higher education in all spheres which transforms the life of students through integration of teaching, research and character building.

MISSION

- To contribute to the development of science and technology by synthesizing teaching,research and creative activities.
- To provide an enviable research environment and state-of-the art technological exposure to its scholars.
- To develop human potential to its fullest extent and make them emerge as world class leaders in their professions and enthuse them towards their social responsibilities.

Department of Electrical Engineering

VISION

Electrical Engineering Department congregates the challenges of new technological advancements to provide comprehensively trained, career focused, morally strong accomplished graduates, cutting edge researchers by experimental learning which contribute to ever changing global society and serve as competent engineers.

MISSION

- To commit excellence in imparting knowledge through incubation and execution of high quality innovative educational programs.
- To develop the Research oriented culture to build national capabilities for excellent power management.
- To inculcate and harvest the moral values and ethical behaviour in the students throughexposure of self -discipline and personal integrity.
- To develop a Centre of research and education generating knowledge and technologies which lay ground work in shaping the future in the field of electrical engineering.

ABOUT THE SCHEME

With a view to enhance the employability skills and impart deep knowledge in emerging areas, usually not being covered in Undergraduate Degree frame work, concept of 'Minor Degree / Specialization' in emerging areas is being introduced from academic session 2023-24. Proposed Minor Degree / Specialization will require the earning of 18 to 20 credits.

This scheme shall be an addition to the regular undergraduate program implying that its passing/failure shall not affect the result of regular undergraduate program being pursued by the student. Upon successful completion of the course, Minor / Specialization Degree shall be awarded to the candidate.

The Electrical Engineering Department of the University has introduced a Minor Degree / Specialization Programme in Electric Vehicle Technology.

NOTE

1. The scheme will be applicable from Academic Session 2023-24onwards.
2. This will be a two-year programme which will start in the 5^{th}sem of the B.Tech.programme.

J. C. BOSE UNIVERSITY OF SCIENCE & TECHNOLOGY, YMCA

FARIDABAD (HARYANA)

Department of Electrical Engineering

Minor Degree Programme in Electric Vehicle Technology

Scheme (2023-24)

Brief description (within 200 words):

The course aims to provide a comprehensive understanding of the basic principles and components of electric vehicles, including the electric drive train, battery technology, charging infrastructure, and energy management systems. This course includes factors that affect range, acceleration, energy consumption, regenerative braking, power electronics selection, energy storage systems, thermal management and overall vehicle efficiency. Students will also learn about the safety considerations specific to electric vehicles, including high-voltage systems, battery management, and crash safety. The course is to equip students with the knowledge and skills necessary to design, analyse, operate, and maintain hybrid vehicles. Additionally, the course may cover maintenance requirements, troubleshooting techniques, design, operation and best practices for maintaining and servicing electric vehicles.

Scheme

Sr. No.	Semester	Course Code	Course Title	L	T	P	Credits	Internal Marks	External Marks	Total
1.	5	MD-EV-501	Fundamentals and Architecture of Electric Vehicles	3	0	0	3	25	75	100
2.	5	MD-EV-551	Fundamentals of Electric Vehicles Lab	0	0	2	1	15	35	50
3.	5	MD-EV-502	Energy Storage Systems for Electric Vehicles	3	0	0	3	25	75	100
4.	6	MD-EV-601	Electric Drives and Controllers for Electric Vehicles	3	0	0	3	25	75	100
5.	6	MD-EV-651	Electric Drives and Controllers Lab	0	0	2	1	15	35	50
6	7	MD-EV-701	Elective	3	0	0	3	25	75	100
7.	7	MD-EV-751	Project (Industry based)	0	0	4	2	15	35	50
8.			MOOC				4			
TOTAL				12	0	8	20	145	405	550

Total Credits - 20

Note: Exams duration will be as under

a. External exams will be of 03 hours duration.
b. Practical exams will be of 02 hours duration

Elective :-

MD-EV-701-A	Testing and Certification of Electric and Hybrid Vehicles
MD-EV-701-B	Modeling and Design of Electric Vehicles
MD-EV-701-C	Automotive Electrical and Electronic Systems
MD-EV-701-D	Plug-in Electric Vehicles in Smart Grid

General Information:

Eligibility/ Target Students	Any B. Tech student who has completed first two years of programme
Duration of program	Two years (20 credits)
Students Intake	Minimum 5
Mode of Delivery (Class Room / MOOC)	Class Room and MOOC
Proposed Fee	As per university rules

Course Code:	**MD-EV-501**
Course Title:	**Fundamentals and Architecture of Electric Vehicles**
Number of Credits:	**Credit 3 (3 L ;0 T; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The course objective of the course is to understand the basic principle, performance and operations of Electric vehicles.

Unit	Contents	Hours
1	**Electric Vehicles** History, Components of Electric Vehicle (EV), General Layout of EV, EV classification Comparison with Internal combustion Engine: Technology, Advantages & Disadvantages of EV.	**4**
2	**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.	**6**
3	**Hybrid Electric Vehicles** History, Components of Hybrid Electric Vehicle, General Layout of Hybrid EV, Comparison with Electric Vehicles, Advantages & Disadvantages of Hybrid EV.	**4**
4	**Vehicle Architecture & Design** Hybrids Based on Architecture, Hybrids Based on Transmission Assembly, Hybrid Based on Degree of Hybridization. Power Train Component Sizing: EV Powertrain sizing, HEV Powertrain Sizing, HEV Powertrain sizing Example.	**8**
5	**Motors and Converter** Principle and working of DC Motor, Characteristics & Types of DC Motors- Overview, Speed Torque characteristics of Permanent magnet Motor, BLDC Motor, Induction motor, Comparison of all motors. Introduction of DC-DC, AC-AC, AC-DC, DC-AC converters, Four quadrant operation, Driver circuits.	**10**

Course Outcomes

The student will be able to:

1. Understand the basic fundamentals of Electric Vehicle.
2. Know the basic fundamentals of Hybrid EV.
3. Learn the concept of motors and converters.

Reference books

1. Electric Vehicle Technology Explained by John Lowry and James Larminie.
2. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, External, and Design by Mehrdad Ehsani and Yimin Gao.
3. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Hussain.
4. Build Your Own Electric Vehicle by Seth Leitman and Bob Brant.
5. Introduction to Hybrid Vehicle System Modeling and Control by Wei Liu.
6. Electric and Hybrid Electric Vehicles by I.Husain ,CRC Press 2003, second edition.
7. Vehicle Propulsion Systems: Introduction to Modeling and Optimization, by L. Guzzella and A. Sciarretta Springer, 2007 Fifth edition.
8. Automotive Transmissions: Fundamentals, Selection, Design and Application G. Lechner and H. Naunheimer Springer, 1999, Third edition.

Course Code:	**MD-EV-551**
Course Title:	**Fundamentals of Electric Vehicles Lab**
Number of Credits:	**1 Credit (0 L ;0 T ; 2 P)**
Internal	**15 Marks**
External	**35 Marks**
Total	**50 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

1. To provide students with hands-on experience in operation and testing electric vehicle systems equipment including electric motors, controllers, and power electronics.
2. To enable students to understand the fundamental principles and operational characteristics of electric equipment/machineries through experimentation and analysis of data.

List of Experiments

1. Experiment for conversion of DC-to-DC voltage using Converter.
2. Simulation for AC-to-AC conversion.
3. Simulation for AC to DC conversion.
4. Simulation for DC to AC conversion.
5. Study of 3-Phase Induction Motor.
6. Speed control of DC motor using IGBT.
7. To perform speed reversal of DC Shunt Motor.
8. Study of various elements of transmission systems (Clutch, Differentials, Gearbox etc.)
9. Calculate and compare the Brake Power, Torque and Mechanical Efficiency of an IC Engine and Electrical Motor of same configuration.
10. Study of various types of Braking systems.
11. Case study of any Electric/ Hybrid car manufactured/sale in India.

Course Code:	**MD-EV-502**
Course Title:	**Energy Storage Systems for Electric Vehicles**
Number of Credits:	**3 Credit (3 L ;0 T; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The course aims to identify suitable energy storage system for Electric Vehicles, compare different energy storage system and explain use of Energy management systems for Energy Storage system.

Unit	Content	Hours
1	**Fundamentals** Introduction to Electrochemical battery, battery capacity, Battery Parameters and Comparisons, Battery Pack Discharge Curves and Aging, Battery Models, SOC, SOD, SOH, DOD, Battery technologies used in recent EVs, Lead acid battery, Nickle based battery, Lithium battery, Grephene battery and comparison of Battery types.	**4**
2	**Fuel Cells** Overview of key Fuel cell technologies, fuel cell types, electrode materials, electrolytes and other components, working principles, Hydrogen generation and storage, limitations, recent progress in Fuel cell technologies, safety issues vs cost aspects, life cycle analysis.	**4**
3	**Ultra-capacitors** Features, basic working principle, fundamentals of Electrochemical super-capacitors, Electrodes, and electrolyte interfaces and capacitances, charge discharge characteristics, Energy/ power density, Design, fabrication, Ultra-capacitor technologies, grephene based Ultra capacitors, Introduction to Flywheel, Hybridization of different energy storage devices.	**5**
4	**Battery Charging** Basic Requirementsfor Charging System, Charger Architectures, Grid Voltages, Frequencies, and Wiring, Charger Functions, Real Power, Apparent Power, and Power Factor, Charging Standards and Technologies, Wireless Charging, Boost Converter for Power Factor Correction: The Boost PFC Power Stage, Sizing the Boost Inductor, Average Currents in the Rectifier, Switch and Diode Average Currents, Switch, Diode, and Capacitor RMS Currents, Power	**7**

	Semiconductors for Charging, Examples.	
5	**Battery and Energy Management Systems** Battery Management Systems: Background of Battery Management Systems, Typical Structure of BMSs, Key Points of BMSs in Future Generation. Energy management strategies, Optimization techniques used in Hybrid and Electric vehicles for Energy storages, classification of Energy Management strategies, comparison and implementation issues of Energy management strategies.	**8**
6	**Battery Charging Station** Types of charging stations, selection and sizing of charging station, components of charging station, single line diagram of charging station, charging station placement for Electric vehicles, Case study of any Indian city for installation and commissioning of a battery charging station.	**6**

Course Outcomes

Students will be able to:

1. Identify suitable energy storage system for Electric Vehicles.
2. Compare different energy storage system.
3. Explain use of Energy management systems for Energy Storage system.

Reference Books

1. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Hussain, CRC Press,2003.
2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles- Fundamentals, External and applications by Mchrdad Ehsani, Yimi Gao, Sebastian E.gay ans Ali Emadi, CRC Press, 2004.
3. Electric Vehicles Technology Explained by james Larminie, John Lowry, Wiley Publications, 2013.
4. Super capacitors- materials, Systems and Applications by F. Beguin and E. Frackowiak, Wiley-VCH Verlag GmbH & Company, 2013.
5. Fuel Cells and Hydrogens: From Fundamentals to applied Research by V. Hacker, S.Mitsushima, Elsevier, 2018.
6. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electricand Fuel Cell Vehicles, By John G. Hayes and G. Abas Goodarzi, Wiley Publication.

Course Code:	**MD-EV-601**
Course Title:	**Electric Drives and Controllers for Electric Vehicles**
Number of Credits:	**3 Credit (3L ;0 T; 0P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The objective of the course is to study about the motor & device characteristics & parameters, to know the various electric drive concepts and to gain knowledge of DC/AC drive mechanism. Also, student may to understand about drives for special electrical machines.

Unit	Contents	Hours
1	**Electric motors** Types of Motors, Selection and sizing of Motor, RPM and Torque calculation of motor Controllers Component s1zmg, Physical locations, Mechanical connection of motor Electrical connection of motor.	**6**
2	**Electric Vehicle Drives** Configurations of Electric Vehicles, Performance of Electric Verucles, Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption.	**6**
3	**Control Unit** Controller Overview, Switch Controller, Solid-State Controller, Electronic Controllers, AC Controller, DC Motor Controller- The Lesson of the Jones Switch, An Off-the-Shelf Curtis PWM DC Motor Controller, AC Controllers.	**6**
4	**Control of Electric Drives** DC Motor Drive, Principle of Operation and Performance, Combined Armature Voltage and Field Control, Chopper Control of DC Motors, Multi quadrant Control of Chopper-Fed, DC Motor Drives, Two-Quadrant Control of Forward Motoring and Regenerative Braking, Single Chopper with a Reverse Switch, Class C Two- Quadrant Chopper, Four-Quadrant Operation, Induction Motor Drives, Basic Operation Principles of induction Motor, Steady-State Performance, Constant Volt/Hertz Control, Power Electronic Control, Field Orientation Control, Direction Rotor Flux Orientation Scheme, Indirect Rotor Flux Orientation Scheme, Voltage Source Inverter for FO,	**10**

	Voltage Control and Current Control in Voltage Source Inverter.	
5	**Permanent Magnetic Brush-Less DC Motor Drives and Case studies** Basic Principles of BLDC Motor Drives, BLDC Machine Construction and Classification Properties of PM Material, Alnico, Ferrites, Rare-Earth PMs, case studies.	**4**

Course Outcomes

The student will be able to :

1. Study about the motor & device characteristics & parameters.
2. Know the various electric drive concepts.
3. Understand DC drive mechanism.
4. Gain knowledge of AC drive mechanism.
5. Learn about drives for special electrical machines.

Reference Books

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, External and Design by M Ehsani, CRC Press,2005.
2. Engine control strategy for a series hybrid electric vehicle incorporating load-leveling and computer controlled, energy management by C.G. Hochgraf, M.J. Ry and H.L. Wiegman Warrendale, PA, 2002
3. Build your own electric vehicle by Seth Leitman Bob Brant, McGrawhills second edition.
4. Automotive Transmissions: Fundamentals, Selection, Design and Application by G. Lechner and H. Naunheimer, Springer third edition.
5. Modem Electric Vehicle Technology by C. C. Chan and K.T. Chau Oxford Science Publication volume II.

Course Code:	**MD-EV-651**
Course Title:	**Electric Drives and Controllers Lab**
Number of Credits:	**1 Credit (0 L ;0 T ; 2 P)**
Internal	**15 Marks**
External	**35 Marks**
Total	**50 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

1. Develop the skills related to Electric Drives and Controllers functions
2. Analyse the important parameters for Electric Drives and Controllers

List of Experiments

1. Demonstration of Wiring layout of Electric Vehicles.
2. Demonstration of Current/ Voltage Control of an Electric Vehicle.
3. Study of Control circuit of an Induction Motor.
4. Demonstration of Controllers and Actuators in Electric Vehicles.
5. Study and Demonstration of Voltage/ Frequency control of Three Phase Induction Motor.
6. Study and demonstration of Speed control of BLDC Motor in Two Wheelers.
7. Demonstration of Speed control of Switched Reluctance Motors (SRM) motor in Three Wheelers.
8. Simulation of Four Quadrant operation of Three Phase Induction motor.
9. Study of MOSFET based Step-up and Step-down Chopper.
10. Study of VI Characteristics of SCR, IGBT, and MOSFET.
11. Study of Three phase IGBT based PWM Inverter control of Induction motor.

ELECTIVES

Course Code:	**MD-EV-701-A**
Course Title:	**Testing and Certification of Electric and Hybrid Vehicles**
Number of Credits:	**3 Credit (3 L;0 T; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The objective of the course is to make students understand the about the of Electric Vehicle certification, the concept of static and dynamic testing of E-vehicle. Also, student learn about various E-vehicle component testing and fundamentals of charging station & Hybrid Electric Vehicle testing.

Unit	Contents	Hours
1	**Introduction** Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.	6
2	**Static Testing of Vehicle** Central Motor Vehicle Rule (CMVR) physical verification, Tyre Tread Depth Test, Vehicle Weighment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement of Temporary Cabin for Drive– Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.	6
3	**Dynamics Testing of Vehicle** Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.	6

4	**Vehicle Component Testing** Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre & Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW	**6**
5	**Tests for Hybrid Electric Vehicles, Retro-Fitment and Charging Station** Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.	**8**

Course Outcomes

The student will be able to:

1.Gain knowledge in the field of E-vehicle certification.

2. Know the concept of static testing of E-vehicle.

3. Understand the concept of dynamic testing of E-vehicle.

4. Study about various Electric-Vehicle component testing.

5. Learn the fundamentals of charging station & hybrid electric vehicle testing.

Reference Books

1. "Vehicle Inspection Handbook", American Association of Motor Vehicle Administrators.
2. Michael Plint & Anthony Martyr, "Engine Testing & Practice", Butterworth Heinmenn, 3rd ed, 2007.
3. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE 4. Bosch Automotive Handbook, Robert Bosch, 7th Edition, 2007.

Course Code:	**MD-EV-701-B**
Course Title:	**Modeling and Design of Electric vehicle**
Number of Credits:	**3 Credit (3 L; 0 T ; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The objective of the course is to make students understand the about the modelling and design of Electric Vehicle. Also, students learn about vehicle dynamics and stability, testing and Vehicular safety and regulations.

Unit	Contents	Hours
1	**Modelling of Electric vehicles** EV and HEV modelling, static and dynamic modelling of battery, Inverter modelling, Electrical motor modelling, Auxiliary load models	5
2	**Design and Manufacturing Criteria** Introduction to body loads: Load cases and load factor, road loads. Driving dynamics and comfort, strength and stiffness of chassis, design features, frame sections, types of frames. Material selection, Fabrication, joining methods, types of joints, welding and brazing, pierce riveting and clinching.	6
3	**Vehicle Dynamics & Stability** Wheels and Tyres: Introduction, Types of wheel rims, wheel dimension, properties of tyre, construction, Tread patterns, Types of tyres, Specifications of tyre. Drag, lifts, resistance, body loads and load calculation, Study principles of Rolling, Pitch & Yaw velocity and moments, aesthetics and ergonomics consideration for stability and control.	7
4	**Vehicle Testing & Homologation** Need of vehicle testing and homologation, testing organizations, testing standards (AIS), Hierarchy of testing: Individual component approval/testing, System level approval and Whole vehicle approval/testing. Conformity of production tests, Crash test, side impact test, rollover test, Impact test, Track testing.	7

5	**Vehicular Safety and Government norms** Road and Automotive Safety Systems: Active and passive safety, Safety Regulations for vehicular application, occupant protection, Traffic signs, traffic rules. Government Norms, Regulations and Policies: Motor vehicle act: control of transport, RTO and other regulations, offences, penalties and procedures.	7

Course Outcomes

The student will be able to:

1. Understand about the modelling and design of Electric Vehicle.
2. Analyse vehicle dynamics and stability.
3. Learn about vehicle testing and homologation.
4. Understand the requirement of vehicular safety systems and road regulations.

Reference Books

1. Vehicle Body Engineering, J. Pawlowski, Business books limited.
2. Fundamentals of Automobile Body Structure Design, Donald E. Malen, SAE International
3. A Textbook of Automobile Engineering-II, P.S.Gill, S.K.Kataria& Sons.
4. Aerodynamics of Road Vehicles, wolf –Heinrich-Hucho, SAE International.
5. Fundamentals of Vehicle Dynamics, Thomas D. Gillespie, Society of Automotive Engineers.
6. Automotive Industrial Standards (AIS).
7. Motor Vehicle Act - Govt. of India Publications.
8. M.V. Act 1988-RTO rules and regulation manual.

Course Code:	**MD-EV-701-C**
Course Title:	**Automotive Electrical and Electronic Systems**
Number of Credits:	**3 Credit (3 L ;0 T ; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The objective of the course is to make students learn about the sensors, starting, ignition and charging systems in automobile. Also, students learn about the components pf chassis electrical system and latest technologies in lighting systems.

Unit	Contents	Hours
1	**Sensors and Actuators** Introduction, Basic Sensor Arrangement, Types of Sensors, Oxygen Sensor, Cranking Sensor, Position Sensor, Engine Oil Pressure Sensor, Linear and Angle Sensor, Flow Sensor, Temperature and Humidity Sensor, Gas Sensor, Speed and Acceleration Sensor, Knock Sensor, Torque Sensor, Yaw Rate Sensors, Tire Pressure Sensor, Actuators.	7
2	**Starting Systems and Ignition Systems** Requirements of the Starting System, Starter Motors and Circuits, Types of Starter Motor, Diagnosing Starting System Faults, Advanced Starting System Technology. Ignition Fundamentals, Types of Ignition System, Electronic Ignition, Programmed Ignition, Distributor Less Ignition, Direct Ignition, Spark-Plugs, Diagnosing Ignition System Faults, Advanced Ignition Technology.	5
3	**Charging Systems and Electronic Fuel Control** Requirements of the Charging System, Charging System Principles, Alternators and Charging Circuits, Diagnosing Charging System Faults, Advanced Charging System Technology. Combustion, Engine Fuelling and Exhaust Emissions, Electronic Control of Carburetion, Fuel Injection Systems, Diesel Fuel Injection, Diagnosing Fuel Control System Faults, Advanced Fuel Control Technology.	6
4	**Lightening Systems and Instrumentation Systems** Lighting fundamentals, Lighting circuits, Gas discharge and LED lighting, Diagnosing lighting system faults, Advanced lighting technology, new developments in lighting systems. Gauges and sensors, Driver information,	8

	Visual displays, GPS, Diagnosing instrumentation system faults, advanced instrumentation technology.	
5	**Chassis Electrical Systems and Auxiliaries** Anti-Lock Brakes, Active Suspension, Traction Control, Automatic Transmission, Other Chassis Electrical Systems, Diagnosing Chassis Electrical System Faults, Advanced Chassis Systems Technology. Windscreen Washers and Wipers, Signalling Circuits, Other Auxiliary Systems, Diagnosing Auxiliary System Faults, Advanced Auxiliary Systems Technology.	6

Course Outcomes

Students will be able to:

1. Understand the concept and working principle of sensors and actuators.
2. Learn about the starting and ignition system and diagnose the ignition system fault of any vehicle.
3. Understand about the charging system components.
4. Learn about the latest technologies present in a lighting systems.
5. Understand about the components of chassis electrical systems and auxiliaries.

Reference books

1. Tom Denton, 'Automotive Electrical and Electronic Systems', Routledge, Taylor and Francis Group, 5th Edition, 2017.
2. Young A.P. and Griffiths. L. 'Automotive Electrical Equipment', ELBS & New Press-1999.
3. William B.Ribbens, 'Understanding Automotive Electronics', 5th edition - Butter worth Heinemann Woburn, 1998.
4. Crouse, W.H. 'Automobile Electrical Equipment', McGraw-Hill Book Co., Inc., New York, 3rd edition, 1986.
5. Kholi.P.L, 'Automotive Electrical Equipment', Tata McGraw-Hill Co., Ltd., New Delhi, 1975.

Course Code:	**MD-EV-701-D**
Course Title:	**PLUG-IN ELECTRIC VEHICLES IN SMART GRID**
Number of Credits:	**3 Credit (3 L ;0 T ; 0 P)**
Internal	**25 Marks**
External	**75 Marks**
Total	**100 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

The course emphasis on the influence of EVs on power system vehicle electrification, impact of charging strategies, frequency control and voltage reserve from EVs. Additionally, the course covers ICT solutions to support EV deployment. the EV charging and facility planning.

Unit	Contents	Hours
1	**Vehicle Electrification & Impact of Charging Strategies** Introduction, Impact of charging strategies, EV charging options and infrastructure, energy, economic and environmental considerations, Impact of EV charging on power grid, effect of EV charging on generation and load profile, Smart charging technologies, Impact on investment.	8
2	**Influence of EV on Power System** Introduction, identification of EV demand, EV penetration level for different scenarios, classification based on penetration level, EV impacts on system demand: dumb charging, multiple tariff charging, smart charging, case studies.	6
3	**Frequency Control Reserves & Voltage Support from EV** Introduction, power system ancillary services, electric vehicles to support wind power integration, electric vehicle as frequency control reserves and tertiary reserves, voltage support and electric vehicle integration, properties of frequency regulation reserves, control strategies for EVs to support frequency regulation.	6

4	**ICT Solutions to Support EV Deployment** Introduction, Architecture and model for smart grid & EV, ICT players in smart grid, smart metering, information & communication models, functional and logical models, technology and solution for smart grid: interoperability, communication technologies.	5
5	**EV Charging Facility Planning** Energy generation scheduling, different power sources, fluctuant electricity, centralized charging schemes, decentralized charging schemes, energy storage integration into Microgrid, Design of V2G Aggregator.	7

Course Outcomes

The student will be able to:

1. Understand vehicle electrification and impact of charging strategies.
2. Learn the influence of EVs on power system.
3. Describe the frequency control and voltage reserve from EVs.
4. Know about the ICT solutions to support EV deployment.
5. Understand the EV charging and facility planning.

Reference Books

1. Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, "Plug in Electric Vehicles in Smart Grids-Integration Techniques", Springer Science + Business Media Singapore Pte Ltd., 2015.

2. Canbing Li, Yijia Cao, Yonghong Kuang and Bin Zhou, "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid", Springer-Verlag Berlin Heidelberg, 2016.

3. Qiuwei Wu, "Grid Integration of Electric Vehicles in Open Electricity Markets", John Wiley & Sons, Ltd, 2013.

Course Code:	**MD-EV-751**
Course Title:	**Project (Industry based)**
Number of Credits:	**2 Credit (0 L ; 0 T ; 4 P)**
Total	**50 Marks**
Offered by Department:	**Electrical Engg. Dept.**

Course Objectives

1. To provide students with hands-on experience in designing and simulating electric and hybrid vehicle systems using state-of-the-art software tools, such as MATLAB/Simulink, PLECS, and ANSYS.

2. To enhance students' understanding of the key concepts related to electric and hybrid vehicles, including power electronics, electric machine design, battery management systems, and vehicle control systems, through practical experimentation and analysis of simulation results.