Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAAC Accredited – 2015
B-Grade CGPA- 2.62

Name of the Faculty: Engineering & Technology

CHOICE BASED CREDIT SYSTEM

SYLLABUS: ELECTRICAL VEHICLE (Honors Degree)

Name of the Course: B. Tech Electrical Engineering

(Syllabus to be implemented w.e.f. June 2021-22)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

Faculty of Engineering & Technology

B.Tech (Electrical Engineering)

PROGRAMME: BACHELOR OF ELECTRICAL ENGINEERING

PROGRAMME OBJECTIVES

A. PROGRAM EDUCATIONAL OBJECTIVES

1. Deliver fundamental as well as advanced knowledge with research initiatives in the field of electrical engineering with emphasis on state of the art technology.
2. Graduates will demonstrate measurable progress in the fields they choose to pursue.
3. Design and develop technically feasible solutions for real world applications which are economically viable leading to societal benefits.
4. To nurture Graduates to be sensitive for ethical, societal and environmental issues while conducting their professional work.

B. PROGRAMME OUTCOMES

Students attain the following outcomes:-

1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11 **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

C. PROGRAMME SPECIFIC OUTCOMES

1 An ability to specify, design and analyze Power System, Electrical Machinery, Electronic Circuits, Drive Systems, Lightning Systems and deliver technological solution by adapting advances in allied disciplines.

2 Apply knowledge of electrical engineering to meet the desired needs within realistic constraints viz. economical, ethical, and environmental and safety.

3 Apply modern software tools for design, simulation and analysis of electrical systems to successfully adapt in multi-disciplinary environments.

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

FACULTY OF ENGINEERING & TECHNOLOGY

Honors Degree – Electrical Vehicle
Branch - Electrical Engineering

WEF batch of 2020-21

Course Code	*Course Name*	*Hrs./week*			*Credits*	*Examination Scheme*			
		L	*T*	*P*		*ISE*	*ESE*	*ICA*	*Total*
SY Sem II									
Hn411	Electric Vehicle Technology	3		2	4	30	70	25	125
TY Sem I									
Hn512	Electric Motors and Controls for Electric Vehicle	3	1		4	30	70	25	125
TY Sem II									
	Seminar			2*	1			25	25
Hn613	Energy Management System for Electric Vehicle	3		2	4	30	70	25	125
B Tech Sem I									
Hn714	Testing And Certification of Electric And Hybrid Vehicles	3		2	4	30	70	25	125
	Mini Project			4*	2		50	50	100
Sub Total		**12**	**1**	**12**	**19**	**120**	**330**	**175**	**625**

* indicates contact hours

Note:

1. Curriculum of Honors specialization can be common between different branches of Engineering
2. Total Credits to be earned for each Honors specialization will be 19 which will be over and above to the overall credits earned in their regular curriculum
3. Students can opt for only one Honors specialization along with their regular curriculum

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

S.Y. B.Tech. Electrical Engineering Semester-II

ELECTRIC VEHICLE TECHNOLOGY

Teaching Scheme	Examination Scheme
Theory: - 3 Hrs/Week, 3 Credits	**ESE -** 70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE –** 30 Marks
	ICA - 25Marks

- **Course Objective:**
  - Provide the basics of hybrid electric vehicle
  - To make the students aware of performance parameters of electric vehicle.
  - Develop awareness for solar powered charging system
  - Make the student aware of mobility and connectors.
- **Course Outcomes: Students' will be able to:**
  - Understand about basics of hybrid electric vehicle
  - Analyze the performance of electric vehicle.
  - Explain environmental aspects of solar powered charging system
  - Understand about mobility and connectors used in charging system.

SECTION I

UNIT I: INTRODUCTION TO ELECTRIC VEHICLE (6 Hrs)

History of electric vehicle, Electric vehicle components, Vehicle mass and performance, electric motor and engine ratings, fuel economy, Electric vehicle market.

UNIT II: VEHICLE MECHANICS (6 Hrs)

Laws of motion, vehicle kinetics, motion dynamics, propulsion power, velocity and acceleration, force mechanics.

UNIT III: CHARACTERISTICS AND PERFORMANCE OF ELECTRIC VEHICLE (9 Hrs)

Electric vehicle configurations, electric motor characteristics, tractive effort and transmission requirements, tractive effort in normal driving, energy consumption and vehicle performance.

SECTION II

UNIT IV: HYBRID ELECTRIC VEHICLE (7 Hrs)

Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Plug-In Hybrid Electric Vehicle, Powertrain Component Sizing, Mass Analysis and Packaging.

UNIT V SOLAR POWERED CHARGING SYSTEM (5 Hrs)

Social Benefits of SPCSs, Environmental Benefits of SPCSs, Economic Benefits, Electric Vehicle Supply Equipment, Locations for SPCSs, Energy Storage, Life Cycle Analysis of SPCSs.

UNIT VI: MOBILITY AND CONNECTORS (9 Hrs)

Mobility - Connected Mobility and Autonomous Mobility, E-Mobility, Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs.

Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,

Reference books:

- Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.
- James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.
- Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
- Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000 .http://nptel.ac.in/courses/108103009/

ICA:

It should consist of minimum 6 experiments based on above syllabus but not restricted to list of experiments given below.

List of Experiments:

1) Modeling and Simulation of DC Motor Characteristics.
2) Modeling and Simulation of Induction Motor Characteristics.
3) Modeling and Simulation of BLDC Motor Characteristics.
4) Modeling and Simulation of energy consumption and performance of electric vehicle.
5) Architecture development of Hybrid Electric Drive Trains.

6) Development of performance analysis of Powertrain Component Sizing for various Electric vehicle configurations
7) Development of mini solar powered charging system.
8) Conduct a case study related with Connected Mobility and Autonomous Mobility

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

T.Y. Electrical Engineering Semester-I

ELECTRIC MOTORS AND CONTROLS FOR ELECTRIC VEHICLE

Teaching Scheme	Examination Scheme
Theory: - 3 Hrs/Week, 3 Credits	**ESE -** 70 Marks
Tutorial: - 1 Hrs/Week, 1 Credit	**ISE –** 30 Marks
	ICA - 25Marks

- **Course Objective:**
  - Provide the basics requirements of Electric Vehicle motors.
  - To understand the various control strategies applied to the motors used in electric vehicle.
- **Course Outcomes: Students' will be able to:**
  - Select appropriate type of motor to be used in electric vehicle.
  - Apply the required control strategy to the Electric Vehicle motors.

SECTION I

UNIT I: ELECTRIC VEHICLE MOTORS (7 Hrs)

Motors (DC, Induction, BLDC) – Types, Principle, Construction, Control. Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives – Basic structure, Drive Convertor, Design

UNIT II: CONVERTER AND CHOPPER CONTROL (8 Hrs)

Principle of phase control – Series and separately excited DC motor with single phase and three phase converters – waveforms, performance parameters, performance characteristics Operation with freewheeling diode schemes; Drive employing dual converter. Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control.

UNIT III: VSI AND CSI FED INDUCTION MOTOR CONTROL (6 Hrs)

AC voltage controller fed induction machine operation – Energy conservation issues – V/f operation theory – requirement for slip and stator voltage compensation. CSI fed induction machine – Operation and characteristics - PWM controls.

SECTION II

UNIT IV: FIELD ORIENTED CONTROL (7 Hrs)

Field oriented control of induction machines – Theory – DC drive analogy – Direct or Feedback vector control - Indirect or Feed forward vector control – Flux vector estimation – Space Vector Modulation control.

UNIT V: DIRECT TORQUE CONTROL (7 Hrs)

Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy – optimum switching vector selection – reduction of torque ripple, methods.

UNIT VI: ELECTRIC VEHICLE CONTROL STRATEGY (7 Hrs)

Vehicle Supervisory Control, Mode Selection Strategy (Parallel mode, Power Split Mode, Engine Brake mode, Regeneration mode), Hybrid Modes, Modal Control Strategy.

Reference Books:

- Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill,2000.
- R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice- Hall of India,Pvt. Ltd., New Delhi, 2003.
- Austin Hughes, "Electric Motors and Drives – Fundamentals, Types and Applications", Elsevier – a division of Reed Elsevier India private Limited, New Delhi, 2006.

ICA:

ICA should consist of minimum **four** assignments based on above syllabus and one mini project related with control of electric motors.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

T.Y. Electrical Engineering Semester-II

SEMINAR

Teaching Scheme	Examination Scheme
Practical: - 2 Hrs/Week, 1 Credit	**ICA –** 25 Marks

ICA

Students should give the seminar on any domain related with recent trends in electric vehicle technology**.**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

T.Y. Electrical Engineering Semester-II

ENERGY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE

Teaching Scheme	Examination Scheme
Theory: - 3 Hrs/Week, 3 Credits	**ESE -** 70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE –** 30 Marks
	ICA - 25Marks

- **Course Objective:**
  - Make the students aware of different types of energy storage system
  - Develop awareness about the battery characteristic & parameters
  - Develop the various types of battery models.
  - Make the student aware of battery testing, disposal and recycling.
- **Course Outcomes:**

Upon the successful completion of the course, student will be able to,

- Discuss about the different types of energy storage system.
- Describe about the battery characteristic & parameters
- Model different types of batteries
- Explain about the battery testing, disposal and recycling.

SECTION I

UNIT I: ENERGY STORAGE SYSTEM (6 Hrs)

Batteries: Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries – Li-ion & Li-poly, Metal Air Battery, Zine Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System.

UNIT II: BATTERY CHARACTERISTICS & PARAMETERS (9 Hrs)

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters- Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries- Meeting battery performance criteria- setting new targets for battery performance.

UNIT-III BATTERY MODELLING (6 Hrs)

General approach to modelling batteries, simulation model of a rechargeable Li-ion battery, simulation model of a rechargeable NiCd battery, Parameterization of the NiCd battery model, Simulation examples.

SECTION II

UNIT IV: BATTERY PACK AND BATTERY MANAGEMENT SYSTEM (10 Hrs)

Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

UNIT V: BATTERY TESTING, DISPOSAL & RECYCLING (11 Hrs)

Chemical & structure material properties for cell safety and battery design, battery testing, limitations for transport and storage of cells and batteries, Recycling, disposal and second use of batteries. Battery Leakage: gas generation in batteries, leakage path, leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells, safety vents, Explosions: Causes of battery explosions, explosive process, Thermal Runway: High discharge rates, Short circuits, charging and discharging. Environment and Human Health impact assessments of batteries, General recycling issues and drivers, methods of recycling of EV batteries.

Reference Books:

- G. Pistoia, J.P. Wiaux, S.P. Wolsky, "Used Battery Collection and Recycling", Elsevier, 2001. (ISBN: 0-444-50562-8)"
- Guangjin Zhao, "Reuse and Recycling of Lithium-Ion Power Batteries", John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
- T R Crompton, "Battery Reference Book-3rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 2000.

- Ibrahim Dinçer, Halil S. Hamut and Nader Javani, “Thermal Management of Electric Vehicle Battery Systems”, JohnWiley& Sons Ltd., 2016.
- Chris Mi, Abul Masrur& David Wenzhong Gao, “Hybrid electric Vehicle- Principles & Applications with Practical Properties”, Wiley, 2011.

ICA:

It should consist of minimum 8 experiments based on above syllabus but not restricted to list of experiments given below.

List of Experiments:

1) Develop a comparative case Study of different types of batteries with their characteristics & detailed specifications.
2) Develop a simulation model for Lead-acid and Li-ion Batteries.
3) Perform Vibration Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
4) Perform Shock Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
5) Perform Short Circuit Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
6) Perform Overcharge Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
7) Perform Roll-Over Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
8) SOC Estimation by Open Source voltage for Lead-Acid battery, Ni-MH battery and Liion battery.
9) SOC Estimation by specific gravity for Lead-Acid battery.
10) SOC Estimation by Coulomb counting method for Lead-Acid battery and Li-ion battery.
11) Design a circuit for Battery monitoring System for Lead acid battery.
12) Design a circuit for passive cell balancing for Li-Ion battery.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.Tech Electrical Engineering Semester-I

TESTING AND CERTIFICATION OF ELECTRIC AND HYBRID VEHICLES

Teaching Scheme	Examination Scheme
Theory: - 3 Hrs/Week, 3 Credits	**ESE -** 70 Marks
Practical: - 2 Hrs/Week, 1 Credit	**ISE –** 30 Marks
	ICA - 25Marks

- **Course Objective:**
  - Provide the information of the various regulations and specifications used in electric vehicle.
  - Develop awareness for testing methods of electric vehicle.
  - Develop the ability to test the various components used in electric vehicle.
- **Course Outcomes: Students' will be able to:**
  - Explain electric vehicle certification procedure.
  - Test the overall performance of electric vehicle.
  - Inspect and test all components used in electric vehicle.

SECTION I

UNIT I: INTRODUCTION (5 Hrs)

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.

UNIT II: STATIC TESTING OF VEHICLE (8 Hrs)

physical verification, Tyre Tread Depth Test, Vehicle Weightment, 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.

UNIT III: DYNAMICS TESTING OF VEHICLE (8 Hrs)

Hood Latch, Grade ability, 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.

SECTION II

UNIT IV: VEHICLE COMPONENT TESTING (11 Hrs)

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<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).

UNIT V: TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION (10 Hrs)

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.

Reference Books:

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

ICA:

It should consist of

- Minimum 2 case studies related with certification and testing
- Minimum three experiments based on above syllabus but not restricted to the list given below.
- Minimum one visit to electric vehicle manufacturing plant.

List of Experiments:

1) Static testing for Angle & Dimensions Measurement.
2) Range and Acceleration test of electric vehicle.
3) Test for Electric Vehicle Conductive AC Charging System.
4) Test for Electric vehicle conductive DC charging system.
5) Demonstration of Safety Requirements.

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

B.Tech Electrical Engineering Semester-I

MINI PROJECT

Teaching Scheme	Examination Scheme
Practical: - 4 Hrs/Week, 2 Credit	**ESE –** 50 Marks **ICA –** 50 Marks

ICA

Students should undertake mini project in their specialization. Batch of size should not be more than four students.