R25-M.TECH (EVT) COURSE STRUCTURE

I SEMESTER

S.No.	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	D251AR01	Power Electronics for Electric Vehicles	3	1	-	4	40	60	100
2	D251AR02	Electric and Hybrid Vehicles	3	1	-	4	40	60	100
3	D251AR03	Automotive Engineering for Electric Vehicles	3	1	-	4	40	60	100
4	**PROGRAM ELECTIVE – I**		3	-	-	3	40	60	100
5	**PROGRAM ELECTIVE – II**		3	-	-	3	40	60	100
Laboratory Courses									
6	D251AR90	EV Simulation Laboratory	-	1	2	2	40	60	100
7	D251AR91	EV motors and controllers Lab	-	1	2	2	40	60	100
8	D2510080	Seminar-1	-	-	2	1	100	-	100
Total			15	05	06	23	380	420	800

List of Professional Elective Courses in I Semester (Electives – I & II)

S.No.	Course Code	Course Title
1	D251ARA0	Vehicular Communication Networks
2	D251ARA1	Sensor Systems for Electric Vehicles
3	D251ARA2	Renewable Energy Technologies
4	D251ARB0	Battery Management Systems
5	D251ARB1	Automotive Embedded Systems
6	D251ARB2	Power Quality enhancement using Custom Power Devices

II SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	D252AR01	EV Charging Technology and Standards	3	1	-	4	40	60	100
2	D252AR02	Special machines for Autonomous Vehicles	3	1	-	4	40	60	100
3	D252AR03	Design, Testing and certification of EV	3	1	-	4	40	60	100
4	**PROGRAM ELECTIVE – III**		3	-	-	3	40	60	100
5	**PROGRAM ELECTIVE – IV**		3	-	-	3	40	60	100
Laboratory Courses									
6	D252AR90	Battery Management Systems Lab	-	1	2	2	40	60	100
7	D252AR91	Vehicular Communication Networks Lab	-	1	2	2	40	60	100
8	D2520080	Seminar-2	-	-	2	1	100	-	100
Total			15	05	06	23	380	420	800

List of Professional Elective Courses in II Semester (Electives III & IV)

S.No.	Course Code	Course Title
1	D252ARA0	Machine Learning for Autonomous Vehicles
2	D252ARA1	Software Development for EVs
3	D252ARA2	IOT Applications in EVs
4	D252ARB0	Smart Grid Interface of Electric Vehicles
5	D252ARB1	Energy Storage Systems for Electric Vehicle
6	D252ARB2	Energy Auditing Conservation & Management

III SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
1	D2530001/M	Research Methodology and IPR / Swayam 12 week MOOC course – RM&IPR	3	-	-	3	40	60	100
2	D253000S	Summer Internship/ Industrial Training (8-10 weeks)	-	-	-	3	100	-	100
3	D25300CV	Comprehensive Viva	-	-	-	2	100	-	100
4	D253000P	Dissertation Part – A	-	-	20	10	100	-	100
Total			3	0	20	18	340	60	400

IV SEMESTER

S.No	Course code	Course Title	Contact hours/week			Credits	Scheme of Valuation		
			L	T	P		CIE	SEE	Total
Theory Courses									
1	D254000P	Dissertation Part – B	-	-	32	16	-	100	100
Total			-	-	32	16	0	100	100

Total Credits: 23+23+18+16= 80

M.Tech.(I Sem) **D251AR01- Power Electronics for Electric Vehicles**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Basics of Power Electronics

Course Objectives: The course aims to provide a comprehensive understanding of modern power semiconductor devices, their characteristics, and gate drive requirements. It focuses on the analysis and design of DC-DC converters and PWM-based inverter systems for efficient power conversion. Additionally, the course introduces multilevel inverter topologies and advanced modulation techniques to enhance performance and application in power electronics systems.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Analyze the static and dynamic characteristics of power semiconductor devices and design suitable gate drive circuits. **(Understand-L2)**

CO2: Design and evaluate the performance of non-isolated DC-DC converters under continuous and discontinuous modes. **(Apply-L3)**

CO3: Apply various PWM techniques to analyze the performance of single-phase and three-phase inverter systems. **(Understand-L2)**

CO4: Compare different multilevel inverter topologies and understand their principles of operation and features. **(Understand-L2)**

CO5: Implement advanced PWM techniques and assess capacitor voltage balancing in multilevel inverters. **(Understand-L2)**

UNIT– I Overview of Switching Devices:

Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.

UNIT– II Non-Isolated DC-DC Converters:

Control of DC-DC converters: Buck converters, Boost converters, Buck-Boost converter, CUK Converter, continuous and discontinuous operation, relation between input and output voltages, design of filter inductor and capacitors, Converter realization with non-ideal components.

UNIT– III PWM Inverters:

Voltage control of single-phase inverters employing phase displacement Control, Bipolar PWM, Unipolar PWM. Three-phase Voltage source inverters: Six stepped VSI operation-Voltage Control of Three-Phase Inverters employing Sinusoidal PWM, Third Harmonic PWM, Space Vector Modulation-Comparison of PWM Techniques- Three phase current source inverters.

UNIT– IV Multilevel Inverters:

Introduction, Multilevel Concept, Types of Multilevel Inverters, Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode Clamped Inverter, Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge Inverter, Comparison of DCMLI & CHB, Modular multilevel converters, principle of operation.

UNIT– V PWM Multilevel Inverters:

CHB Multilevel Inverter: Stair case modulation-SHE PWM- Phase shifted Multicarrier modulation-Level shifted PWM- Diode clamped multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.

Text Books

1.Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M Undeland,William P. Robbins, John Wiley& Sons, 3rd Edition, 2022.

2.Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First Indian Reprint-4th Edition,2017

3. High-power converters and AC drives -Wu, Bin, and Mehdi Narimani-John Wiley & Sons, 2nd edition, 2016.

Reference Books:

1.Elements of Power Electronics – Philip T. Krein, Oxford University press, 2nd edition , 2017.

2.Power Electronics Daniel W. Hart - McGraw-Hill, 2017.

M.Tech.(I Sem) **D251AR02- Electric and Hybrid Vehicles**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Electrical Circuits and Electrical Machines.

Course Objectives: The course aims to provide fundamental knowledge of electric and hybrid vehicles, including their evolution, drive-train topologies, and motor drive configurations. It focuses on energy storage systems and energy management strategies to improve efficiency and performance. The course also develops the ability to analyze and design components of modern electric and hybrid vehicle systems.

Course Outcomes: At the end of the course, the student will be able to:

CO1: Understand the fundamentals, performance characteristics, and environmental impact of electric and hybrid vehicles. **(Understand-L2)**

CO2: Analyze different hybrid drive-train topologies and evaluate power flow and fuel efficiency. **(Understand-L2)**

CO3: Apply control strategies to configure various motor drives used in electric and hybrid vehicles. **(Understand-L2)**

CO4: Analyze energy storage systems and determine appropriate sizing of propulsion components. **(Understand-L2)**

CO5: Evaluate different energy management strategies and compare their implementation in hybrid and electric vehicles. **(Understand-L2)**

UNIT-I: Overview of Electric and Hybrid Vehicles

History of hybrid and electric vehicles, - Social and environmental importance of hybrid and electric vehicles - Impact of modern drive-trains on energy supplies - Basics of vehicle performance, vehicle power source characterization Transmission characteristics.

UNIT-II: Drive Train Topologies

Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies Power flow control in hybrid drive-train topologies -Fuel efficiency analysis.

UNIT-III: Configuration and control of Motor drives

Introduction to electric components used in hybrid and electric vehicles -Configuration and control of DC Motor drives - Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives, Configuration and control of Switched Reluctance Motor drives, drive system efficiency.

UNIT-IV: Energy Storage

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics. Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Ultra Capacitors, Hybridization of different energy storage devices.

UNIT-V: Energy Management Strategies

Introduction to energy management and their strategies used in hybrid and electric vehicles- Classification of different energy management strategies- Comparison of different energy management strategies- Implementation issues.

TEXT BOOKS:

1.C. C. Chan, K. T. Chau, "Modern Electric Vehicle Technology" published by Oxford University Press,1st Edition , 2001.

2.Chris Mi, M. AbulMasrur and David WenzhongGao, "Hybrid Electric Vehicles: Principles and

Applications with Practical Perspectives" John Wiley Ltd. Publication, 2nd Edition.
3.Iqbal Husain "ELECTRIC and HYBRID VEHICLES Design Fundamentals" CRC PRESS Boca Raton London New York Washington, D.C.,3rd Edition, 2021.

REFERENCES:

1.Rodrego Garcia-valle and J. A. P Lopes "Electric Vehicle Integration into Modern Power Networks" Springer, 2012.
2.Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design" CRC Press, 3rd Edition, 2022
3.NITI Aayog, Ministry of Power, Department of Science and Technology, Bureau of Energy Efficiency ,"Handbook of Electric Vehicle Charging Infrastructure Implementation" WRI India, Ross Center.

M.Tech.(I Sem) **D251AR03- Automotive Engineering for Electric Vehicles**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Engineering Physics, Basic Electrical and Electronics Engineering.

Course Objectives: The course aims to provide comprehensive knowledge of conventional vehicle systems, including chassis, transmission, braking, and steering mechanisms. It focuses on analyzing vehicle performance, subsystems, and emerging technologies such as advanced suspension and battery systems. The course also develops the ability to evaluate design considerations and operational efficiency of automotive systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand vehicle fundamentals, forces acting on vehicles, and analyze engine performance and emission characteristics. **(Understand-L2)**

CO2: Compare different chassis, suspension, and wheel configurations and evaluate their advantages and limitations. **(Understand-L2)**

CO3: Analyze transmission system configurations and differentiate various powertrain components and Differential types. **(Understand-L2)**

CO4: Evaluate braking systems and analyze advanced safety systems used in modern vehicles. **(Understand-L2)**

CO5: Understand steering mechanisms and analyze battery systems, including performance and degradation aspects. **(Understand-L2)**

UNIT – I Conventional vehicle systems and configurations:

Fundamentals of vehicle, modelling of vehicle-various forces acting on it, components of conventional vehicle and propulsion load; Drive cycles and drive trains; Engine components and systems, four stroke engines, engine performance, air pollution, emission norms.

UNIT – II Chassis, Body, Dampers, Types of suspension systems and Wheels and tires:

Chassis and Body: Frames – Conventional, Semi-Integral, Integral type, Chassis - Ladder frame, Backbone, Monocoque, Tubular chassis. Advantages and disadvantages.

Suspension system: Springs: coil springs, leaf springs & torsion bars.

Dampers: Hydraulic dampers, Nitrox dampers, Telescopic and USD suspensions, MR and ER dampers.

Types of suspension systems: rigid axle and independent suspensions, air suspension systems, electronic suspension systems, electromagnetic suspension, active and passive suspension systems.

Wheels and tires: Types of wheels, Front /rear wheel drive configurations - Four/All-wheel drive configurations.

UNIT – III Transmission system:

Power train configurations, components, features, advantages and disadvantages, hub motor direct drive configuration, centrally mounted configuration, differential- classification and types.

UNIT – IV Braking systems:

Drum brakes, disc brakes, hydraulic brakes, power-assisted brake, air brakes, electric brakes, anti-lock braking system (ABS), electronic brake force distribution system (EBD), regenerative braking, brake assist system. Supplementary restraint system, air bags, pyrotechnic inflator, air bag control unit.

UNIT – V Steering system:

Steering mechanism, steering geometry, steering gears, power-assisted steering hydraulic power steering (HPS), electric power hydraulic steering (EPHS), electric power steering (EPS).

Batteries: Types of batteries, constructional details, thermal management of batteries, vent management system, Battery life analysis, Battery performance Degradation.

Reference Books:

1.H. Heisler, Advanced Vehicle Technology, 2nd ed. Butterworth–Heinemann, 2011

2.M Ehsani, Y Gao, L K Ebrahimi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, 3rd Edition,Taylor and Francis, 2019.

3.Tom Denton, Electric and Hybrid Vehicles , Routledge, 3rd Edition ,2024.

4.W. H. Crouse and D. L. Anglin, Automotive Transmission and Power Trains construction, McGraw Hill, 6th edition, 1983.

5.W. H. Crouse and D. L. Anglin, Automotive mechanics, Tata McGraw-Hill, 10th edition ,2017.

6.K. Newton, W. Steeds, and T. K. Garret, Motor Vehicle, Butterworth-Heinemann, 12th edition,1996.

7.M Matschinsky, Road Vehicle Suspensions, Wiley, ISBN: 978-1-860- 58202-8, 1998.

8.J Jiang, C Zhang, Fundamentals and Applications of Lithium-ion Batteries in Electric Drive Vehicles, Wiley, 1st edition,2015

9.V. Sajith and S. Thomas, Internal Combustion Engines, Oxford University Press, 1st ed. 2017.

M.Tech.(I Sem) **D251ARA0- Vehicular Communication Networks**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Communication Networks, Wireless Communication Systems

Course Objectives: The course aims to provide fundamental knowledge of Vehicular Ad-hoc Networks (VANETs), including their architecture, communication technologies, and safety applications. It focuses on mobility modeling, wireless communication aspects, and routing protocols for vehicular environments. The course also introduces standards and regulations governing vehicular communication systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand the fundamentals, architecture, and safety applications of VANET systems. **(Understand-L2)**

CO2: Analyze various vehicular mobility and traffic models used in VANET environments. **(Understand-L2)**

CO3: Analyze physical and MAC layer issues and evaluate wireless communication techniques for VANETs. **(Understand-L2)**

CO4: Compare different routing protocols and analyze their suitability for vehicular networks **(Understand-L2)**

CO5: Understand VANET standards and interpret regulations related to DSRC communication systems. **(Understand-L2)**

UNIT-I: Introduction and Cooperative Vehicular Safety Applications:
Basic Principles and Challenges, Past and Ongoing VANET (Vehicular Ad-hoc network) Activities, Enabling Technologies, Cooperative System Architecture, VANET-enabled Active Safety Applications.

UNIT-II: Vehicular Mobility Modeling for VANET:
Random Models, Flow Models – Microscopic flow models, Macroscopic flow models, Mesoscopic flow models, Lane changing models; Traffic Models – Trip planning, Path planning, Influence of time; Behavioral Models, Trace or Survey-based Models.

UNIT-III: Physical Layer & MAC Layer Considerations for Vehicular Communications:
Wireless Propagation Theory – Deterministic multipath models, Statistical multipath models, Path loss modelling; Channel Metrics – Delay spread, Coherence bandwidth, Doppler spread, Coherence time, Impact on OFDM systems; A Survey on Proposed MAC Approaches for VANETs - Time-division, Space-division, Code-division; Communication based on IEEE 802.11p.

UNIT-IV: Routing Protocols:
Ad-hoc routing - Proactive routing protocols, Reactive routing protocols; Geographic routing - Geographic routing, Virtual-coordinate-based routing; Geocasting - ETSI GeoNetworking, Decentralized environmental notification messages, Topology-assisted geo-opportunistic routing.

UNIT-V: Standards and Regulations:
Layered Architecture for VANETs - General concepts and definitions, A protocol stack for DSRC; DSRC Regulations, DSRC Physical Layer Standard, DSRC Data Link Layer Standard (MAC and LLC).

TEXTBOOKS

1.H. Hartenstein and K. P. Laberteaux, VANET: Vehicular Applications and Inter-Networking Technologies, Wiley, 2010.

Chirstoph Sommer, Falko Dressler, Vehicular Networking, Cambridge University Press, 1st edition, 2014

REFERENCE BOOKS:

1.H. Moustafa, Y. Zhang, Vehicular Networks: Techniques, Standards, and Applications, CRC Press, 1st edition, 2009.

2.Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, Vehicular ad hoc Networks: Standards, Solutions, and Research, Springer, 2016.

M.Tech.(I Sem) **D251ARA1 - Sensor Systems for Electric Vehicles**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic Electrical and Electronics Engineering, Digital Electronics, Signals and Systems, Microprocessors and Microcontrollers.

Course Objectives: The course aims to provide fundamental knowledge of sensors and actuators, including their characteristics, classifications, and applications in measurement systems. It focuses on various types of sensors, such as thermal, optical, electrical, mechanical, and smart sensors, along with their working principles. The course also emphasizes interfacing techniques and circuits for integrating sensors with microprocessor-based systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand sensor fundamentals, classifications, and analyze performance characteristics of sensors and actuators. **(Understand-L2)**

CO2: Analyze temperature and optical sensors and differentiate their working principles and applications. **(Understand-L2)**

CO3: Apply concepts of electrical, magnetic, and mechanical sensors to measure physical parameters. **(Understand-L2)**

CO4: Understand chemical, MEMS, and smart sensors and analyze their applications in modern systems. **(Understand-L2)**

CO5: Design interfacing circuits and implement methods for integrating sensors with microprocessor-based systems. **(Understand-L2)**

Unit-I: Sensor fundamentals and characteristics

Definitions, Classification of sensors and actuators, General requirements for interfacing, Performance characteristics of sensors and actuators

Unit-II: Temperature & Optical sensors

Temperature sensors: Thermo-resistive sensors, Thermoelectric sensors, p–n junction temperature sensors.

Optical sensors: Quantum-based optical sensors, Photoelectric sensors, Charge coupled (CCD) sensors and detectors, Active far infrared (AFIR) sensors, Optical actuators.

Unit-III: Electric, magnetic and mechanical sensors

Electric and magnetic sensors: Capacitive sensors – Capacitive position, proximity, and displacement sensors, Inductive sensor, eddy current sensor, Hall effect sensor, Voltage and current sensors.

Mechanical sensors: Force sensor, Acceleration sensor, Pressure sensor, Velocity sensor.

Unit-IV: Chemical, MEMS and smart sensors

Chemical sensors: Electrochemical sensors, Thermochemical sensors.

MEMS and smart sensors: MEMS sensors, Smart sensors, Wireless sensors and actuators and issues associated with their use, RFIDs and embedded sensors.

Unit-V: Interfacing circuits and methods

Interfacing circuits: Amplifiers, Power amplifiers, Digital circuits.

Interfacing methods: The microprocessor as a general-purpose controller, General requirements for interfacing sensors and actuators.

Text Books:

1.Nathan Ida, Sensors, Actuators and their interfaces, Second Edition, 2020, IET

2.Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", Springer, New York, 5th edition, 2015.

M.Tech.(I Sem) **D251ARA2 - Renewable Energy Technologies**

L	T	P	Cr.
3	0	0	3

Pre requisite: Power Electronics.

Course Objectives: The course aims to provide comprehensive knowledge of renewable energy sources and distributed generation systems, focusing on their economic and operational aspects. It emphasizes the analysis of energy conversion technologies such as wind, photovoltaic systems, induction generators, and fuel cells. The course also develops the ability to evaluate control strategies and performance of renewable energy-based power systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand renewable energy concepts and analyze economic and management aspects of power systems. **(Understand-L2)**

CO2: Analyze the operation of induction generators and evaluate their performance under different conditions. **(Understand-L2)**

CO3: Evaluate wind power plant design factors and analyze wind energy conversion systems. **(Understand-L2)**

CO4: Analyze photovoltaic systems and apply MPPT techniques for efficient energy extraction. **(Understand-L2)**

CO5: Understand fuel cell technologies and evaluate their performance and practical implementation aspects. **(Understand-L2)**

UNIT– I: Introduction:

Renewable Sources of Energy; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Control of renewable energy-based power Systems

UNIT– II: Induction Generators:

Principles of Operation; Representation of Steady-State Operation; Power and Losses Generated - Self-Excited Induction Generator; Magnetizing Curves and Self-Excitation - Mathematical Description of the Self-Excitation Process; Interconnected and Stand-alone operation - Speed and Voltage Control.

UNIT– III: Wind Power Plants:

Site Selection; Evaluation of Wind Intensity; Topography; Purpose of the Energy Generation- General Classification of Wind Turbines; Rotor Turbines; Multiple-Blade Turbines; Drag Turbines; Lifting Turbines - Generators and Speed Control Used in Wind Power Energy; Analysis of Small wind energy conversion system.

UNIT– IV: Photovoltaic Power Plants:

Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell on Temperature and irradiance input-output Characteristics - Equivalent Models and Parameters for Photovoltaic Panels; MPPT schemes: P&O,INC, effect of partial shaded condition. Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy

UNIT– V Fuel Cells:

The Fuel Cell; Low- and High-Temperature Fuel Cells; Commercial and Manufacturing Issues - Constructional Features of Proton Exchange-Membrane Fuel Cells; Reformers; Electrolyzer Systems; Advantages and Disadvantages of Fuel Cells - Fuel Cell Equivalent Circuit; Practical Determination of the Equivalent Model Parameters; Aspects of Hydrogen for storage

Text Books:

1.Felix A. Farret, M. Godoy Simo` es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2nd edition, 2017

2.Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 1st edition, 2011.

Reference Books:

1.Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 3rd edition, 2023

M.Tech.(I Sem) **D251ARB0- Battery Management Systems**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic knowledge of electrochemistry, circuit theory, and electrical energy systems.

Course Objectives: The course aims to provide in-depth knowledge of electrochemical batteries, their characteristics, modeling, and performance analysis. It focuses on battery technologies, equivalent circuit modeling, and selection criteria for electric and hybrid vehicles. The course also emphasizes optimal control strategies, safety, and efficiency improvement of battery systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand electrochemical battery principles and compare different battery technologies based on performance characteristics. **(Understand-L2)**

CO2: Analyze equivalent circuit models and evaluate battery parameters using experimental data. **(Understand-L2)**

CO3: Develop battery models and simulate their behavior under various operating conditions. **(Understand-L2)**

CO4: Select suitable batteries for EVs/HEVs and analyze battery management and SOC estimation methods. **(Understand-L2)**

CO5: Evaluate optimal control strategies and analyze safety and degradation mechanisms in battery systems. **(Understand-L2)**

UNIT-I: Introduction to Electrochemical batteries

Electrochemical reactions, Thermodynamic voltage, Specific Energy, Specific Power, Energy efficiency. Battery Specifications.

Batteries: construction and operation of Lead Acid Battery, Nickel based batteries, Sodium based batteries, Lithium based batteries– Li-ion & Li-poly, Metal Air Battery, Zinc Chloride battery; comparison of performance characteristics.

UNIT-II: Equivalent-Circuit Models

Open-circuit voltage, State-of-charge dependence, Equivalent series resistance, Diffusion voltages, Rough parameter values, Warburg impedance, Hysteresis voltages, enhanced self-correcting cell model, Equipment for cell-data collection, tests to determine OCV relationship.

UNIT-III: Modelling of Batteries

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.

UNIT-IV: Battery Selection

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.

UNIT-V: Optimal Control of Battery

Battery Optimal Controls, Minimizing degradation, Solid Electrolyte Interface (SEI) formation and growth, SEI Reduced Order Model (ROM) results, Lithium plating on overcharging. Plating ROM results, Optimized power limits, Plug-in charging, Fast-charge example, Dynamic power calculation. Battery communication channel, Battery Pack Safety, Battery Standards.

TEXT BOOKS

1.Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition", CRC Press, 2nd edition, 2009.
2.Gregory L. Plett, Battery Management Systems Volume I Battery Modeling, 2015.
3.Gregory L. Plett, Battery Management Systems Volume II Equivalent-Circuit Methods, 2016
4.T R Crompton, "Battery Reference Book-3 rd Edition", Newnes- Reed Educational and Professional Publishing Ltd., 1990
5.Chris Mi, Abul Masrur& David Wenzhong Gao, "Hybrid electric Vehicle- Principles & Applications with Practical Properties", Wiley, 3rd edition, 2025.
6.James Larminie, John Lowry, "Electric Vehicle Technology Understanded", John Wiley & Sons Ltd, 2nd edition, 2012

M.Tech.(I Sem) **D251ARB1 - Automotive Embedded Systems**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic understanding of embedded systems, microcontrollers.

Course Objectives: The course aims to provide a comprehensive understanding of embedded systems in the automotive domain, including architectures, communication protocols, and software development practices. It focuses on AUTOSAR architecture, safety standards, and reliability aspects of automotive systems. The course also emphasizes testing and verification methodologies used in modern automotive embedded applications.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand embedded system architectures and analyze their characteristics and challenges. **(Understand-L2)**

CO2: Analyze automotive communication protocols and apply embedded software development concepts. **(Understand-L2)**

CO3: Understand AUTOSAR architecture and analyze its software layers and components. **(Understand-L2)**

CO4: Evaluate automotive safety standards and analyze reliability concepts in embedded systems. **(Understand-L2)**

CO5: Apply testing and verification techniques and evaluate automotive system quality using standards like ASPICE. **(Understand-L2)**

UNIT-I: Embedded Systems Overview:

Components of an Embedded System; Functional Domains, Standardized components and models, Typical Embedded System Architectures; Characteristics, Concepts and Challenges.

UNIT-II: Embedded Automotive Protocols and Embedded Software:

Embedded Automotive Protocols: Automotive Communication Systems – car domains, CAN, LIN, and FlexRay Protocols; V-model;

Embedded Software: Basic concepts of software product lines, Reuse of software, Requirements for the reuse of software in the automotive domain, Model based development – Role of MBD in automotive embedded systems and Potential benefits of MBD

UNIT-III: AUTOSAR Architecture:

AUTOSAR Basics; Autosar Software Components & Application Layers. Basic Software Layer, MCAL Layer, Services Layer, Diagnostics, Memstack, AUTOSAR RTE, AUTOSAR OS & C Rules.

UNIT-IV: Safety and Reliability:

Automotive Functional Safety Concepts, Overview of ISO26262, Different safety standards & levels.

UNIT-V: Testing and Verification for Automotive Systems:

Automotive SPICE (ISO/IEC 15504); Testing in Virtual Environments; XiL Testing - Model in Loop, Hardware in Loop, Software in Loop.

TEXTBOOKS

1.Simonot-Lion, F., & Navet, N. (Eds.). Automotive Embedded Systems Handbook CRC Press. https://doi.org/10.1201/9780849380273, 1st edition, 2017.

2.AUTOSAR [on line]. Available on: www.autosar.org.

3.Soner gulbas, SPICE. Automotive SPICE® Process Reference and Assessment Model [on line]. RELEASE [Consultation: 16/05/2018]. Available on:2026.

4.https://www.automotivespice.com/fileadmin/software-download/Automotive_SPICE_PAM_30.pdf

REFERENCE BOOKS:

1.International Organization for Standardization. ISO/DIS 26262. Road Vehicles - Functional Safety [online]. 2009 [Consultation: 16/05/2018]. Available on: https://www.iso.org/obp/ui/#iso:std:iso:26262:-2:dis:ed-2:v1:en.

2.Koomen, Tim; Van der Aalst, Leo; Broekman, Bart; Vroon, Mitchiel. TMap Next, for result-driven testing. Tutein Nolthenius, Uitgeverij, ISBN 9789072194800, 1st edition, 2014.

M.Tech.(I Sem)	D251ARB2 - Power Quality enhancement using Custom Power Devices	L	T	P	Cr.
		3	0	0	3

Pre requisite: Knowledge on electric circuit analysis, power systems, power electronics.

Course Educational Objectives: The course aims to provide a comprehensive understanding of power quality issues, their causes, and impacts on electrical systems. It focuses on analysis of voltage disturbances, harmonics, and mitigation techniques using advanced compensation methods. The course also emphasizes the application of custom power devices for improving power quality in modern power systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand power quality concepts and analyze various types of power quality disturbances. **(Understand-L2)**

CO2: Analyze transient and long-duration voltage variations and evaluate protection and regulation techniques. **(Understand-L2)**

CO3: Analyze harmonic distortion and design suitable mitigation techniques using filters and standards. **(Understand-L2)**

CO4: Understand custom power devices and analyze their role in improving power quality. **(Understand-L2)**

CO5: Apply custom power devices and evaluate their performance in enhancing power quality in power systems. **(Understand-L2)**

UNIT– I Introduction to power quality:

Overview of Power Quality, Concern about the Power Quality, General Classes of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, Power Frequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources of voltage and current interruptions, Nonlinear loads.

UNIT– II Transient and Long Duration Voltage Variations:

Source of Transient Over Voltages - Principles of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor Switching Transients, Utility Lightning Protection, Load Switching Transient Problems.

Principles of Regulating the Voltage, Device for Voltage Regulation, Utility Voltage Regulator Application, Capacitor for Voltage Regulation, End-user Capacitor Application, Regulating Utility Voltage with Distributed generation

UNIT– III Harmonic Distortion and solutions:

Voltage vs. Current Distortion, Harmonics vs. Transients - Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Sources of harmonics, Locating Sources of Harmonics, System Response Characteristics, Effects of Harmonic Distortion, Inter harmonics, Harmonic Solutions Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Harmonic Filter Design, Standards on Harmonics

UNIT– IV Custom Power Devices:

Custom power and custom power devices, voltage source inverters, reactive power and harmonic compensation devices, compensation of voltage interruptions and current interruptions, static series and shunt compensators, compensation in distribution systems, interaction with distribution equipment, installation considerations.

UNIT– V Application of custom power devices in power systems:

Static and hybrid Source Transfer Switches, Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic Voltage Restorer (DVR), Operation and control of Interline Power Flow Controller (IPFC), Operation and control of Unified Power Quality Conditioner (UPQC), Generalized power quality conditioner.

Text Books:

1.Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 3rd edition, 2017.
2.Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press, 2011.
3.Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4.Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, ArindamGhosh, Kluwer Academic Publishers, 2012

Reference Books:

1.Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
2.Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2016.
3.Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York, 1993
4.Power Quality c.shankaran, CRC Press, 1st edition, 2017
5.Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis).
6.Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier,1st edition, 2008
Power Quality, C. Shankaran, CRC Press, 2001
7.Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press, 2007.
8.Custom Power Devices - An Introduction, ArindamGhosh and Gerard Ledwich, Springer, 2002
9.A Review of Compensating Type Custom Power Devices for Power Quality Improvement, Yash Pal et.al., Joint International Conference on Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008.

M.Tech.(I Sem) **D251AR90 - EV Simulation Laboratory**

L	T	P	Cr.
0	1	2	2

Pre-requisite: Basics of Electrical Machines and Drives, Control Systems, Power Electronics and Battery and Energy Systems.

Course Objectives: The course aims to develop practical skills in modeling and simulation of electric and hybrid vehicle systems. It focuses on analyzing vehicle performance, motor drives, battery systems, and energy management using simulation tools. The course also enhances the ability to evaluate the impact of various parameters on EV performance.

Course Outcomes: At the end of the course, student will be able to:

CO1: Apply simulation tools to model and analyze the performance of electric and hybrid vehicle systems under varying conditions. **(Apply-L3)**

CO2: Evaluate the impact of vehicle parameters such as mass, rolling resistance, and aerodynamic drag on vehicle range and efficiency. **(Apply-L3)**

CO3: Analyze the performance of electric motor drives and compare different control strategies used in EV applications. **(Apply-L3)**

CO4: Develop and assess models for battery management, regenerative braking, and hybrid vehicle configurations. **(Apply-L3)**

List of Experiments:

1. Develop a simulation model to analyse the effect of Rolling Resistance on vehicle range and Performance
2. Develop a simulation model to analyze the effect of vehicle mass on vehicle range and Performance
3. Develop a simulation model to analyze the effect of Aerodynamic drag and Hill Climbing force on vehicle range and Performance
4. Simulation study and analyze the performance of speed control of Induction motor drives in EV.
5. Simulation study and analyze the performance of speed control of PMDC and BLDC motor drives in EV.
6. Simulation study of LV/High current electric motor drives with BLDC or PMSM drive.
7. Develop a simulation model to analyze Electric Motor Regenerative Braking Characteristics for different Driving Cycles.
8. Simulation study of Battery Management System in EV
9. Develop a simulation model for Series/parallel HEV to analyze the effect of changing of parameters on vehicle range and performance.
10. Simulation study of data acquisition system of EV

M.Tech.(I Sem) **D251AR91- EV motors and controllers Lab**

L	T	P	Cr.
0	1	2	2

Pre-requisite: Power Electronics fundamentals, Basics of Electrical Machines and Drives

Course Objectives: The course aims to provide hands-on knowledge of controlling various electric motor drives using power electronic converters. It focuses on implementing advanced control strategies such as V/f control, field-oriented control, direct torque control, and sensorless techniques. The course also develops the ability to analyze and compare the performance of induction, synchronous, PMSM, BLDC, and switched reluctance motor drives under different operating conditions.

Course Outcomes: At the end of the course, student will be able to:

CO1: Apply control techniques to implement speed control of induction, synchronous, and special motor drives using power electronic converters. **(Apply-L3)**

CO2: Analyze the performance of various motor control strategies such as V/f control, Field Oriented Control, and Direct Torque Control. **(Apply-L3)**

CO3: Compare different motor drives (IM, PMSM, BLDC, SRM) and evaluate their dynamic and steady-state performance. **(Apply-L3)**

CO4: Develop and assess closed-loop and sensorless control schemes for efficient motor drive operation. **(Apply-L3)**

List of Experiments:

1. Open loop V/f control of a three-phase induction motor.
2. Closed loop V/f control of a three-phase induction motor.
3. Field oriented control of three phase induction motor.
4. Sensorless Field oriented control of three-phase induction motor with MRAS based speed estimation.
5. Direct Torque control of three-phase induction motor.
6. Speed control of Synchronous Motor drive with three-phase inverter.\
7. Speed control of PMSM drive with three-phase inverter by using Sine-PWM in open loop.
8. Speed control of PMSM drive with three-phase inverter by using Sine-PWM in closed loop.
9. Speed control of PMSM drive with three-phase inverter by using Field Oriented Control.
10. Speed control of BLDC drive with three-phase inverter in open loop.
11. Speed control of BLDC drive with three-phase inverter in closed loop.
12. Speed control of switched reluctance motor drive.

M.Tech.(II Sem) **D252AR01- EV Charging Technology and Standards**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Basic knowledge of electrical power systems, electric vehicles, and renewable energy integration.

Course Objectives: The course aims to provide comprehensive knowledge of electric vehicle (EV) charging infrastructure, including location planning, charging technologies, and system design. It focuses on charging standards, communication interfaces, and emerging concepts such as V2G and wireless charging. The course also develops an understanding of policies and strategies for large-scale EV adoption.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand EV charging infrastructure planning and analyze criteria for selecting charging locations. **(Understand-L2)**

CO2: Describe EV charging technologies and differentiate between various charging methods and configurations. **(Understand-L2)**

CO3: Analyze different charging modes and standards and select appropriate EVSE and communication protocols. **(Understand-L2)**

CO4: Understand advanced charging concepts such as V2G and wireless charging and analyze communication interfaces. **(Understand-L2)**

CO5: Evaluate EV policies and analyze their impact on EV adoption and infrastructure development. **(Understand-L2)**

Unit-I: Overview of EV charging Location

EV Charging Location Selection-Location Selection criteria - Public charging stations-Guidelines on Charging Infrastructure-Design On-Grid solar charging stations for a parking lot-Electric Vehicle Charging Safety Guidelines.

Unit-II: Introduction to EV Charging Technology

Basic charging Block Diagram of Charger-Difference between Slow charger and fast Charger-On-board charging and Off-board charging-AC charging vs DC charging.

Unit-III: Modes of Charging

Levels of EV charging, AC charging - Type 1,2,3-DC charging - CHAdeMO, Tesla, CCS- Fast charging and its Limitations-Smart charging and applications.

Electric Vehicle Supply Equipment (EVSE): Different types of EV charger connectors-single-phase or three-phase socket-CHAdeMO standard - DC fast Charging-Selection of EVSE Communication Protocol (PLC / Ethernet / Modbus/ CAN Module)-National & International EV Standard Codes.

Unit-IV: Communication Interface

Introduction of Vehicle to grid (V2G) technology- Introduction to Wireless charging of EV-Inductive Charging Static and Dynamic-Battery swap Technology-Communication Interface between charger and Central Management System.

Unit-V: Policies for EV adoption

The nature and scope of policies to stimulate widespread EV adoption and support EVCI station implementation; policy formulation and implementation at various levels of government; examples of policies and incentives for EV adoption-replacement of the gasoline tax funding source in an increasingly electrified environment.

TEXTBOOKS

1.Charging the Future Challenges and Opportunities for Electric Vehicle Adoption, Henry Lee Harvard Kennedy School Alex Clark Climate Policy Initiative, September 2018 RWP18-026.
2.Electric Vehicle Charging Station Guidebook Planning for Installation and Operation, June 2014, CCRPC EV Charging Installation Guide.

REFERENCE BOOKS:

1. HANDBOOK of ELECTRIC VEHICLE CHARGING INFRASTRUCTURE IMPLEMENTATION Version 1, NITI AYOG, WRI INDIA., 2022.

M.Tech.(II Sem) **D252AR02 - Special machines for Autonomous Vehicles**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Basic knowledge of electrical machines, power electronics, and electric vehicle fundamentals.

Course Objectives: The course aims to provide in-depth knowledge of advanced electric motor drives used in electric vehicles, including PM brushless, PMSM, SRM, and magnet-less motor technologies. It focuses on modeling, control strategies, and design considerations for efficient drive systems. The course also develops the ability to evaluate different motor drive technologies for EV applications.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand the structure and operation of PM brushless motor drives and analyze their design for EV applications. **(Understand-L2)**

CO2: Analyze PMSM drives and apply vector and sensorless control techniques for efficient operation. **(Understand-L2)**

CO3: Understand SR motor drives and evaluate their control strategies and performance in EV systems. **(Understand-L2)**

CO4: Analyze stator-PM motor drive topologies and compare their features and applications. **(Understand-L2)**

CO5: Evaluate advanced magnet-less motor drives and analyze their suitability for EV applications. **(Understand-L2)**

UNIT-I: Permanent Magnet (PM) Brushless Motor Drives:

Structure of PM Brushless Machines, Principle of PM Brushless Machines Modeling of PM Brushless Machines, Inverters for PM Brushless Motors Motor Control, Design Criteria of PM Brushless Motor Drives for EVs, Design Examples of PM Brushless Motor Drives for EVs, Application, Advantages and Limitations for EVs.

UNIT-II: Permanent Magnet Synchronous Motor Drives:

Operation of PMSM, PMSM Block Diagram and Control, vector control of PMSM, sensor less control of PMSM, Design Criteria of PMSM Drives for EVs, Design Examples of PMSM Drives for EVs, Application, Advantages and Limitations for EVs .

UNIT-III: Switched Reluctance Motor drives:

Structure of SR Machines, Principle of SR Machines, SR Converters Topologies, SR Motor Control, Design Criteria of SR Motor Drives for EVs, Examples of SR Motor Drives for EVs, Application, Advantages and Limitations for EVs.

UNIT-IV: Stator-PM Motor Drives:

Doubly-Salient PM Motor Drives, Flux-Reversal PM Motor Drives, Flux-Switching PM Motor Drives, Hybrid-Excited PM Motor Drives Flux-Mnemonic PM Motor Drives, Design Criteria of Stator-PM Motor Drives for EVs, Application, Advantages and Limitations for EVs.

UNIT-V: Advanced Magnet Less Motor Drives:

Introduction of Progressive Magnet less technology, Synchronous Reluctance Motor Drives, Doubly-Salient DC Motor Drives, Flux-Switching DC Motor Drives, Design Criteria of Advanced Magnet Less Motor Drives for EVs, Application, Advantages and Limitations for EVs.

TEXTBOOKS

1.K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, IEEE Press, Wiley, 1st edition, 2015.
2.Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1993, Oxford.

REFERENCE BOOKS:

1.Mehrdad Ehsani, Yimin Gao, Sebatien Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2.James Larminie and John Loury, Electric Vehicle Technology – Understanded, John Wiley & Sons Ltd, 2003.
3.T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London,1988.

M.Tech.(II Sem) **D252AR03 - Design, Testing and certification of EV**

L	T	P	Cr.
3	1	0	4

Pre-requisite: Basic understanding of electric vehicles, vehicle systems, and automotive regulations.

Course Objectives: The course aims to provide comprehensive knowledge of standards, regulations, and safety requirements for electric and hybrid vehicles. It focuses on testing procedures, charging standards, retrofitment guidelines, and battery safety aspects. The course also develops an understanding of government policies and regulatory frameworks supporting EV adoption.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand electric powertrain standards and analyze testing and measurement procedures for EV performance. **(Understand-L2)**

CO2: Describe EV charging and HEV standards and differentiate between AC/DC charging systems. **(Understand-L2)**

CO3: Understand retro fitment standards and analyze regulatory requirements for EV conversion systems. **(Understand-L2)**

CO4: Analyze safety requirements of traction batteries and evaluate automotive certification standards. **(Understand-L2)**

CO5: Understand government policies and evaluate their impact on electric mobility adoption. **(Understand-L2)**

UNIT-I: Introduction:

Electric power train vehicles-construction and functional safety requirements measurement of electrical energy consumption, Method of measuring the range, Measurement of net power and the maximum 30 minute power, CMVR type approval for electric power train vehicles, ISO 26262.

UNIT-II: Charger Standard:

Electric Vehicle Conductive AC Charging System, Electric Vehicle Conductive DC Charging System. HEV Standard: CMVR Type Approval for Hybrid Electric Vehicles, CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW > 3500 kg

UNIT-III: Retro fitment Standards:

CMVR Type Approval of Hybrid Electric System Intended for Retro fitment on Vehicles of M and N Category having GVW <= 3500 kg and GVW > 3500 kg. CMVR Type Approval of Electric Propulsion Kit Intended for Conversion of Vehicles for Pure Electric Operation.

UNIT-IV: Safety Requirement of Traction Battery:

Introduction to Vehicle safety standards, Rules and Regulations, Environmental impurities and safety requirements, Battery Operated Vehicles -Safety Requirements of Traction Batteries, Automotive safety components certification by various organizations (ARAI, SIAM, SAE, ASME, FMVSS).

UNIT-V: Government Policies:

National Electric Mobility Mission Plan 2020 (NEMMP2020), Faster Adoption and Manufacture of (Hybrid and Electric Vehicles) – FAME, Niti Aayog Report on Transforming Mobility.

REFERENCE BOOKS:

1.Automotive Industry Standards, India, 2015-2016 Other References:
2.https://araiindia.com
3.https://emobility.araiindia.com
4.https://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf

5.https://niti.gov.in/content/national-mission-transformative-mobility-and-battery-storage
6.https://niti.gov.in/writereaddata/files/document_publication/NITI-RMI_India_Report_web-v2.pdf

M.Tech.(II Sem) **D252ARA0 - Machine Learning for Autonomous Vehicles**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Fundamental knowledge of vehicle dynamics, sensors, and basic machine learning or AI concepts.

Course Objectives: The course aims to provide a comprehensive understanding of autonomous vehicle systems, including sensing, perception, and decision-making processes. It focuses on machine learning and deep learning techniques for object detection, classification, and environment understanding. The course also develops the ability to design intelligent decision-making and trajectory planning algorithms for self-driving vehicles.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand levels of vehicle autonomy and analyze the role of sensors and perception systems in autonomous vehicles. **(Understand-L2)**

CO2: Describe machine learning paradigms and apply them to object detection and classification tasks. **(Understand-L2)**

CO3: Analyze supervised learning algorithms and apply them for classification and regression problems in autonomous systems. **(Understand-L2)**

CO4: Apply deep learning techniques and analyze perception tasks in self-driving vehicle applications. **(Understand-L2)**

CO5: Analyze decision-making strategies and design trajectory planning algorithms for autonomous vehicles. **(Understand-L2)**

UNIT-I: Introduction:

Levels of autonomy in automobiles - Levels 0 through 5. Subsystems required for embedding intelligence into automobiles such as sensors, feedback control, software and hardware architecture etc. Sensors, perception and visualization for decision making

UNIT-II: Automotive Machine Learning for Autonomous Vehicles:

Introduction – Types of Learning Paradigms: Supervised, and Unsupervised Learning, and their applications: object detection, object recognition, object classification, and object localization.

UNIT-III: Supervised Learning:

Classification (Detection and Classification of Objects, K-Nearest-Neighbor, Bayesian Classification: Naive Bayes, Decision Trees, Overfitting, Random Forests, SVM, Multiclass & Ordinal Classification, Kernels. Dimensionality Reduction: Feature Extraction & Selection Regression: Instance based learning: Linear Regression, Sensitivity Analysis, Multivariate Regression.: Linear Classification, Logistic Regression

UNIT-IV: Deep Learning for Self-Driving Cars:

Perception: Camera, LiDAR, RADAR, Sensor Fusion.

Applications: Lane Line Detection, Road Segmentation, Obstacle Detection, Traffic-Signs/Light Detection, Road Marking, Distance Estimation, Driver Monitoring, Multi-Object Tracking.

UNIT-V: Decision making and trajectory planning:

Principles of decision making- Heuristic approach and approximation approach; Trajectory planning: Graph based approach, Choice of best trajectory based on real-time data and tracking; various algorithms and their working principles for decision making and trajectory planning.

TEXTBOOKS:

1.Pattern Recognition and Machine Learning by Christopher Bishop
2.Machine Learning by Tom Mitchell
3.Autonomous Vehicle Driverless Self-Driving Cars and Artificial Intelligence: Practical Advances in AI and Machine Learning by Eliot et. al.
4.Applied Deep Learning and Computer Vision for Self-Driving Cars by Sumit Ranjan.
5.Machine Learning, Tom Mitchell, McGraw Hill, 1st edition, 2017.
6.Pattern Recognition and Machine Learning, Bishop, C. (2006), Berlin: Springer-Verla.

REFERENCES:

1.Introduction to Machine Learning, Ethem Alpaydin, 4th Edition, 2020
2.Machine Learning for Hackers, Drew Conway & John Miles Wine,1st edition, 2012.
3.Duda, Hart and Stork, Pattern Classification 2nd Edition Wiley Inter Science, 2000

M.Tech.(II Sem) **D252ARA1- Software Development for EVs**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic Electrical and Electronics Engineering, Digital Electronics, Signals and Systems, Microprocessors and Microcontrollers.

Course Objectives: The course aims to provide comprehensive knowledge of software systems used in electric and autonomous vehicles, including battery management, powertrain control, and vehicle integration. It focuses on advanced control, energy management, and ADAS functionalities for efficient and safe vehicle operation. The course also develops the ability to analyze and design software architectures for intelligent automotive systems.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand BMS software functions and analyze techniques for SoC, SoH estimation and battery safety. **(Understand-L2)**

CO2: Analyze powertrain control strategies and apply motor control algorithms for efficient vehicle operation. **(Understand-L2)**

CO3; Understand VCU software architecture and analyze subsystem integration and supervisory control functions. **(Understand-L2)**

CO4: Evaluate energy management strategies and analyze their impact on vehicle efficiency and performance. **(Understand-L2)**

CO5: Apply ADAS and autonomous driving concepts and analyze perception, decision-making, and control algorithms. **(Understand-L2)**

Unit-I: Battery Management System (BMS) Software

Purpose: Manages the state, health, and safety of the battery pack.
Functions: State of Charge (SoC) estimation, State of Health (SoH) monitoring, thermal management, cell balancing, fault detection.
Examples: Altair Battery Designer, BatteryCAD

Unit-II: Powertrain Control Software

Purpose: Controls the electric motor and power electronics to optimize performance and efficiency.
Functions: Motor control algorithms (FOC, DTC), inverter management, regenerative braking control.
Examples: dSPACE Automotive Simulation Models (ASM), Simulink (MATLAB) for model-based design, etc.

Unit-III: Vehicle Control Unit (VCU) Software

Purpose: Integrates various subsystems (e.g., BMS, powertrain, HVAC) and coordinates their operation.
Functions: Supervisory control, energy management, diagnostics, and fault tolerance. Examples: ETAS INCA, Vector CANoe for network simulation and testing.

Unit-IV: Energy Management Software

Purpose: Optimizes the use of energy within the vehicle to enhance efficiency and performance.
Functions: Energy distribution between battery and auxiliary systems, thermal management.
Examples: AVL CRUISE, Autonomie by Argonne National Laboratory

Unit-V: Advanced Driver Assistance Systems (ADAS) and Autonomous Driving Software

Purpose: Enhances driving safety and enables autonomous driving capabilities.
Functions: Perception (sensor data processing, object detection), decision making (path planning, obstacle avoidance), control (adaptive cruise control, lane keeping).
Examples: NVIDIA DRIVE, Apex.AI

References:

1."Electric Vehicle Technology Understanded" by James Larminie and John Lowry,2012
2."Battery Management Systems for Large Lithium Ion Battery Packs" by Davide Andrea, 1st edition, 2010
3."Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives" by Chris Mi, 2nd edition, 2017
4."Advanced Electric Drive Vehicles" by Ali Emadi, 2017
5."Autonomous Driving: Technical, Legal and Social Aspects" by Markus Maurer et al, 1st edition, 2016

M.Tech.(II Sem)

D252ARA2- IOT Applications in EVs

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic understanding of electric vehicle systems, microcontrollers, and IoT communication protocols.

Course Objectives: The course aims to provide comprehensive knowledge of IoT technologies and their applications in electric and autonomous vehicles. It focuses on IoT-enabled battery management, powertrain optimization, and energy management systems. The course also develops an understanding of IoT security, data management, and its role in ADAS and autonomous driving.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand IoT concepts and analyze their applications and communication protocols in EV systems. **(Understand-L2)**

CO2: Analyze IoT-enabled battery management systems and apply techniques for real-time monitoring and diagnostics. **(Understand-L2)**

CO3: Evaluate IoT-based powertrain and energy management systems and analyze their impact on efficiency. **(Understand-L2)**

CO4: Analyze IoT security challenges and evaluate data management techniques in EV applications. **(Understand-L2)**

CO5: Apply IoT concepts in autonomous driving and analyze perception, communication, and control systems. **(Understand-L2)**

Unit-I: Introduction to IoT in EVs:

Definition, history, and evolution of Io, Key concepts and terminologies in IoT, Role and imp in electric vehicles, Applications of IoT in EV systems, Layers of IoT architecture (sensing, co processing, and application), Components of an IoT system (sensors, actuators, gateways Overview of communication protocols (Wi-Fi, Bluetooth, Zigbee, LoRa, NB-IoT, etc.), Prot to vehicular networks (V2V, V2I, V2X).

Unit-II: IoT for Battery Management and Monitoring:

Architecture and components of IoT-enabled BMS, Data acquisition from battery cells Techniques for real-time monitoring of battery parameters (voltage, current, temperature),Usin and gateways for data collection, Predictive Analytics, Remote Diagnostics.

Unit-III: IoT for Powertrain and Energy Management

Role of IoT in powertrain control and optimization, Key parameters monitored by IoT (motor efficiency), IoT-based energy management systems (EMS), Real-time data acquisition and p energy optimization, Smart Charging, Predictive Maintenance

Unit-IV: IoT Security and Data Management in EVs

Common security threats in IoT-enabled EVs, Vulnerabilities in IoT components and commu Encryption techniques for secure data transmission, Intrusion detection and prevention s acquisition, storage, and processing in IoT systems, Cloud and edge computing for IoT data Privacy and Compliance

Unit-V: IoT for Autonomous Driving and ADAS

IoT in Autonomous Vehicles, Role of IoT in enabling autonomous driving, Key IoT compon functions in autonomous vehicles, Perception Systems, IoT sensors for perception (LiDAR, ra ultrasonic sensors), Data fusion and processing for environment understanding, Vehicle Co Vehicle-to-Everything (V2X) communication using IoT, Protocols and standards for V2X co Control Systems, IoT-based control systems for autonomous driving, Real-time data processin making.

Reference Books:

1."Internet of Things: Principles and Paradigms" by Rajkumar Buyya and Amir Vahid Dastjerdi,1st edition, 2000.
2."Building the Internet of Things" by Maciej Kranz, 2016
3."IoT and Edge Computing for Architects" by Perry Lea, 2020
4."Connected Vehicles: Intelligent Transportation Systems" by Radovan Miucic, 1st edition, 2018
5."The Fourth Industrial Revolution" by Klaus Schwab, 2017

M.Tech.(II Sem) **D252ARB0- Smart Grid Interface of Electric Vehicles**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic knowledge of electrochemistry, circuit theory, and electrical energy systems.

Course Objectives: The course aims to provide a comprehensive understanding of smart grid concepts and the integration of electric vehicles into modern power systems. It focuses on V2G technology, power conversion, and control strategies for efficient grid operation. The course also develops the ability to analyze EV charging technologies and their impact on distributed energy resources.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand smart grid concepts and analyze the role of EVs and V2G technology in modern power systems. **(Understand-L2)**

CO2: Analyze the impact of EV penetration on electrical networks and evaluate its effects on renewable energy systems. **(Understand-L2)**

CO3: Analyze power conversion technologies and develop models for EV integration with smart grid nodes. **(Understand-L2)**

CO4: Evaluate power control and monitoring strategies and analyze the impact of EVs on grid stability. **(Understand-L2)**

CO5: Understand EV charging technologies and analyze V2G interfaces and distributed generation systems. **(Understand-L2)**

UNIT-I: Introduction to the Smart Grid using EVs

The Smart Grid and Microgrid, Impact of EVs on Distributed Energy Resources in the Smart Grid, V2G Technology and PEVs Charging Infrastructures.

UNIT-II Impact of EV and V2G on the Smart Grid and Renewable Energy Systems

Types of Electric Vehicles, Motor Vehicle Ownership and EV Migration, Impact of Estimated EVs on Electrical Network, Impact on Drivers and the Smart Grid

UNIT-III Power Conversion Technology in the Smart Grid and EV

Dynamical Modeling of EV Connected to Single-Phase Smart Grid Node, Dynamical Modeling of EV Connected to Three-Phase Smart Grid Node, Power Conversion Problem Formulation in Smart Grids with EVs.

UNIT-IV Power Control and Monitoring of the Smart Grid with EVs

Impacts of EV Penetration on Grid Power Profile and Requirements of Its Control and Monitoring Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid. Voltage and Frequency Regulation, Supporting and Balancing of Intermittent RES.

UNIT-V EV Charging Technologies and V2G on Distributed Systems and Utility Interfaces

Vehicle-to-Grid Concept and EV Communication Requirements, Distributed Generation and the Smart Grid, Charging Diversity and Utility Interfaces, Local, Central and Distributed Generation, Current PEV Charging Standards, Socket Types, Contact-Based PEV Charging, Rectifier Topologies for G2V, Inverter Topologies for V2G, DC/DC Converters.

TEXT BOOKS

1.Hossain, Jahangir Lu, Junwei, "Vehicle-to-Grid Linking Electric Vehicles to the Smart Grid," Published by The Institution of Engineering and Technology, London, United Kingdom, 2015.

2.Qiuwei Wu, "Grid integration of Electric vehicles in Open electricity markets, " John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom,1st edition

2013.
3.Canbing Li, Yijia Cao, Yonghong Kuang Bin Zhou, "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid," Jointly published with Science Press, Beijing and Springer-Verlag Berlin Heidelberg, 1st edition, 2016.

M.Tech.(II Sem) **D252ARB1- Energy Storage Systems for Electric Vehicle**

L	T	P	Cr.
3	0	0	3

Pre-requisite: Basic knowledge of electrical machines, electrochemistry, and electric vehicle fundamentals.

Course Objectives: The course aims to provide comprehensive knowledge of energy storage technologies used in electric vehicles, including batteries, fuel cells, and hybrid storage systems. It focuses on modeling, selection, management, and safety aspects of energy storage systems. The course also develops the ability to design and evaluate energy storage solutions for efficient EV applications.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand various energy storage technologies and analyze their modeling and applications in EVs. **(Understand-L2)**

CO2: Analyze fuel cell technologies and evaluate their system integration and performance. **(Understand-L2)**

CO3: Select appropriate battery technologies and analyze performance parameters for EV applications. **(Understand-L2)**

CO4: Analyze battery management systems and evaluate safety and lifecycle considerations. **(Understand-L2)**

CO5: Design energy storage systems and apply charging and testing methods for EV applications **(Understand-L2)**

UNIT – I: Overview of Energy Storage Technologies for EVs:

Introduction to Energy Storage Requirements in Electric Vehicles - Different types of energy storage; Mechanical: Flywheel based energy storage; Chemical: Hydrogen production and storage; Electrical: Capacitors for EV, Super Capacitor, EDLC; Electrochemical: battery, fuel cell, biological, thermal; Magnetic Energy Storage, Superconducting Energy Storage systems, Hybridization of different energy storage devices. Modelling of various emerging storage systems – Simulation case studies.

UNIT – II: Fuel Cell Technologies and System Integration:

Introduction and overview of fuel cells technology: low, medium and high temperature fuel cells - Types of fuel cells, liquid and methanol types, proton exchange membrane fuel cell, solid oxide, Microbial fuel cell, Thermodynamics of fuel cells, Fuel cell modeling-simulation and case studies, system integration, Safety issues and cost expectation and life cycle analysis of fuel cells, Placement of storage systems.

UNIT – III: Battery Selection and Performance Parameters:

Selection of battery cell and types, Standardized sizes and shapes pertaining to both primary and secondary batteries, Selection of Key technical terms: End of life, Depth of Discharge (DoD), State of Charge (SoC), Cycling rate (C-rate), Study of Battery critical parameters selection (voltage of cell, Specific energy, Charge and Discharge rate, Cycle life, current density), Cell equalization problem. Thermal runaway, Battery series parallel connection and string size. Measurement, estimation and tracking of SoC.

UNIT – IV: Battery Management Systems and Safety:

Battery mounting arrangement and installation methodology. State of health and charging efficiency and its effect on life cycle for various C-rates. Different battery management strategies, chemical properties, charge balancing, recyclability, salt based batteries, solid state batteries, battery packaging, safety considerations. Combination of super capacitor and battery – the application perspective.

UNIT – V: Energy Storage System Design and Applications:

Design and Applications of Energy Storage - Battery sizing and stand-alone applications, Constant current and constant voltage charging methods, Hybrid Methods, Inductive chargers, Battery power testing for various vehicles, Battery testing for urban and highway driving cycles, Battery management systems and controls, control of charge discharge cycles.

Case studies. Combination of super capacitor and battery – the application perspective.

REFERENCES

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2. F. A. Silva and M. P. Kazmierkowski, "Energy Storage Systems for Electric Vehicles [Book News]," in IEEE Industrial Electronics Magazine, vol. 15, no. 4, pp. 93-94, Dec. 2021.

3. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), 2011.

4. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, 2nd edition, 2009.

5. Electric Power Research Institute (USA), "Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits" (1020676), December 2010.

6. Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan, "The Role of Energy Storage with Renewable Electricity Generation", National Renewable Energy Laboratory (NREL) – A National Laboratory of the U.S. Department of Energy – Technical Report NREL/ TP6A2-47187, January 2010.

7. Kim, Y., & Chang, N. (2014). Design and management of energy-efficient hybrid electrical energy storage systems. Cham, Switzerland: Springer International Publishing.

8. Rufer, Alfred. Energy storage: systems and components. CRC Press, 2nd edition, 2026.

9. Viral, R., Tomar, A., Asija, D., Rao, U.M., & Sarwar, A. (Eds.). (2022). Smart Grids for Renewable Energy Systems, Electric Vehicles and Energy Storage Systems ,CRC Press., 1st edition, 2024

L	T	P	Cr.
3	0	0	3

M.Tech.(II Sem) **D252ARB2- Energy Auditing Conservation & Management**

Pre-requisite: Electrical power systems and measurements.

Course Objectives: The course aims to provide fundamental knowledge of energy auditing and management practices for efficient utilization of energy resources. It focuses on energy-efficient systems, power factor improvement, and the use of energy measurement instruments. The course also develops the ability to perform economic analysis for energy conservation and cost optimization.

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand energy audit principles and analyze energy consumption patterns in industrial and utility systems. **(Understand-L2)**

CO2: Describe energy management practices and apply strategies for effective energy planning and monitoring. **(Understand-L2)**

CO3: Analyze energy-efficient motors and lighting systems and evaluate their performance and energy savings. **(Understand-L2)**

CO4: Apply power factor improvement techniques and analyze the use of energy measurement instruments. **(Understand-L2)**

CO5: Evaluate economic aspects of energy conservation and analyze investment decisions using financial methods. **(Understand-L2)**

UNIT– I: Basic Principles of Energy Audit

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams and load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT– II: Energy Management

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manager, qualities and functions, language, Questionnaire – check list for top management

UNIT– III: Energy Efficient Motors and Lighting

Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics – variable speed , variable duty cycle systems, RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice, lighting control, lighting energy audit

UNIT– IV: Power Factor Improvement and energy instruments

Power factor – methods of improvement, location of capacitors, Power factor with non-linear loads, effect of harmonics on p.f, p.f motor controllers – Energy Instruments- watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's

UNIT– V: Economic Aspects and their computation

Economics Analysis depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, lifecycle costing analysis – Energy efficient motors. Calculation of simple payback method, net present value method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

Text Books:

1.Energy management by W.R.Murphy&G.Mckay Butter worth, Heinemann publications, 1982.

2.Energy management hand book by W.CTurner, John Wiley and sons, 9th Edition, 2020

Reference Books:

1.Energy efficient electric motors by John.C.Andreas, Marcel Dekker Inc Ltd-,1982
2.Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3.Energy management and good lighting practice: fuel efficiency- booklet12-EEO

M.Tech.(II Sem) **D252AR90- Battery Management Systems Lab**

L	T	P	Cr.
0	1	2	2

Pre-requisite: Basics of Electrical Machines and Power Electronics, Control Systems and Embedded Systems Fundamentals

Course Objectives: The course aims to provide practical knowledge of battery modeling, simulation, and management systems used in electric vehicles. It focuses on analyzing battery performance parameters, charging methods, and DC-DC/AC-DC converter-based systems. The course also develops skills in designing battery packs and implementing battery management systems using communication protocols.

Course Outcomes: At the end of the course, student will be able to:

CO1: Apply simulation tools to model and analyze battery characteristics, parameters, and charging/discharging behavior. **(Apply-L3)**

CO2: Analyze and evaluate battery management systems, including passive and active BMS techniques. **(Apply-L3)**

CO3: Design battery packs and implement power electronic converters for efficient battery operation. **(Apply-L3)**

CO4: Apply communication protocols and analyze the impact of battery charging systems on power systems. **(Apply-L3)**

LIST OF EXPERIMENTS

(Any 10 experiments)

1. Simulation of Equivalent circuit of a lead-acid and Lithium-Ion Battery.
2. Simulation of battery parameters measurement and estimation (Voltage, Current, SoC).
3. Simulation of battery parameters measurement and estimation (Depth of Discharge, State of Health, State of Power).
4. Simulation of Passive battery management systems.
5. Simulate the Active battery management systems.
6. Simulate the Charging and discharging characteristics of a Battery.
7. Simulate Ni-MH Battery Model with the DC machine and show the charging and discharging process using DC machine.
8. Simulate Closed-loop Implementation of Bi-directional DC-DC Converter with two batteries.
9. Design the 2 Series, 4 Parallel Battery pack with passive BMS circuit.
10. Design 4 Series, 4Parallel Battery pack design with active BMS.
11. Implementation of CAN (Controller Area Network) protocol on active and Passive BMS.
12. Simulation of Battery Charging by using non isolated DC – DC converter
13. Simulation of Battery Charging by using AC – DC converter
14. Simulation of battery charging system to analyse its impact on power system

M.Tech.(II Sem) **D252AR91- Vehicular Communication Networks Labs**

L	T	P	Cr.
0	1	2	2

Pre-requisite: Basics of Embedded Systems and Microcontrollers (e.g., Arduino), Fundamentals of Wireless Sensor Networks and IoT.

Course Objectives: The course aims to provide practical knowledge of IoT and vehicular communication systems, including sensor interfacing, data acquisition, and cloud integration. It focuses on wireless sensor networks, communication protocols, and automotive networking standards. The course also develops skills in implementing and testing IoT-based and vehicle communication applications.

Course Outcomes: At the end of the course, student will be able to:

CO1: Apply IoT concepts to interface sensors, acquire data, and develop embedded applications. **(Apply-L3)**

CO2: Analyze wireless communication protocols such as MQTT, V2X, and IEEE 802.11p for vehicular networks. **(Apply-L3)**

CO3: Develop and test IoT network applications and cloud-based data communication systems. **(Apply-L3)**

CO4: Apply automotive communication protocols like CAN and UDS and analyze ECU network performance. **(Apply-L3)**

Any 10 of the following experiments are to be conducted.

List of experiments

1. Familiarization of Hardware Components of Wireless Sensor Networks (WSNs) and Configuration of Xbee using XCTU Software. (Components: Arduino Boards, Xbee modules, Sensors, Xbee Explorer, IoT interface/bridge, WiGuy Routers, Switch, etc.)
2. Coding the Arduino Board for different Sensors.
3. Measurement and collection of sensor values
4. Development of program to upload sensor values to the cloud through HTTP.
5. IOT Network Protocol – MQTT (Message Queuing Telemetry Transport).
6. Collection of Measured Data at the Coordinator (Centralized node).
7. Development of IOT Network Application and Testing.
8. Performance Testing of V2X Interface.
9. Performance Testing of VCN (Vehicular Communications and Networking) Protocol – IEEE
10. 802.11 P.
11. Conduct CAN (Controller Area Network) communication and ECU network in EV
12. Conduct UDS (Unified Diagnostic Services) - vehicle dynamics
13. Perform ECU (Electronic Control Unit) simulation, automotive V & V using CAN tools.

M.Tech.(III Sem) **D2530001/M- Research Methodology and IPR**

L	T	P	Cr.
3	0	0	3

Pre-requisites: Knowledge in Engineering, English

Course Objective: To understand the research problem, to know the literature studies, plagiarism and ethics, to get the knowledge about technical writing, to analyse the nature of intellectual property rights and new developments and research related information and to know the patent rights.

Course Outcomes: At the end of the course, student will be able to:
CO1: Analyze the research problem and its formulation. **(Understand-L2)**
CO2: Analyze the significance of research ethics **(Understand-L2)**
CO3: Apply the information technology for better tomorrow and to develop creativity. **(Understand-L2)**
CO4: Identify the importance of intellectual property rights to be promoted among students in general & engineering in particular **(Understand-L2)**
CO5: Understand the IPR protection for new and better products, and in turn brings about, economic growth and social benefits. **(Understand-L2)**

UNIT I- RESEARCH PROBLEM AND SCOPE FOR SOLUTION
Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT II- FORMAT
Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT III- PROCESS AND DEVELOPMENT
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting andDevelopment: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

UNIT IV- PATENT RIGHTS
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT V- NEW DEVELOPMENTS IN IPR
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS
1.Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2.Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3.Ranjit Kumar, 4th Edition, "Research Methodology: A Step by Step Guide for beginners", 2024

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2.Mayall, "Industrial Design", McGraw Hill, 1992.
3.Niebel, "Product Design", McGraw Hill, 1974.
4.Asimov, "Introduction to Design", Prentice Hall, 1962.
5.Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2023
6.T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008