Academic Program: PG

Academic Year 2025-26

Electrical & Electronics Engineering (Lead Department)

Jointly with

Electronics & Communication Engineering

Mechanical Engineering

Electric Vehicle Technology

I & II Semester M. Tech.

Syllabus

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous InstituteApproved by AICTE & Affiliated to VTU, Belagavi)
Ph: 0836-2447465Fax: 0836-2464638 Web: www.sdmcet.ac.in

College Vision and Mission

Vision:

To develop competent professionals with human values.

Mission:

1. To have contextually relevant Curricula.
2. To promote effective Teaching Learning Practices supported by Modern Educational Tools and Techniques.
3. To enhance Research Culture.
4. To involve Industrial Expertise for connecting classroom content to real life situations.
5. To inculcate Ethics and impart soft-skills leading to overall Personality Development.

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

Department Vision and Mission

Vision:

To develop globally acceptable Electrical and Electronics Engineering professionals with human values.

Mission:

1. Adopting the state of the art curricula
2. Practicing effective and innovative teaching-learning methodologies
3. Initiating complementary learning activities to enhance competence
4. Inculcating positive attitude and commitment to society.

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for I & II semester M.Tech in Electric Vehicle Technology is recommended by the Board of Studies of Electrical & Electronics Engineering, Electronics & Communication Engineering and Mechanical Engineering Departments and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2025-26 till further revision.

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Chairmen BoS & HoDs **Principal**

Program Educational Objectives (PEOs):

The Program Educational Objectives (PEOs):

I. To prepare graduates who will be successful professionals in industry, government, academia, research, entrepreneurial pursuit and consulting firms.

II. To prepare graduates who will contribute to society as broadly educated, expressive, ethical and responsible citizens with proven expertise.

III. To prepare graduates who will achieve peer-recognition; as an individual or in a team; through demonstration of good analytical, research, design and implementation skills.

IV. To prepare graduates who will thrive to pursue life-long reflective learning to fulfil their goals.

Program Outcomes (POs):

PO1: An ability to independently carry out research / investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report / document.

PO3: Student should be able to demonstrate a degree of mastery over the area of Electric Vehicle Technology.

PO4: Exposure to the state of the art practices in the domain of Electric Vehicle Technology.

Scheme of Teaching and Examinations – 2025-26
M. Tech. (Electric Vehicle Technology)
I Semester M.Tech.

Course	Course Code	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
BSC	24PEVC100	Applied Mathematics	3-0-0	3	50	100	3	-	-
PCC	24PEVC101	Electric Machines and Drives for EVs	3-0-0	3	50	100	3	-	-
PCC	24PEVC102	Automotive Technology	3-0-0	3	50	100	3	-	-
PCC	24PEVC103	Electric Vehicle Dynamics and Aerodynamics	3-0-0	3	50	100	3	-	-
PCC	24PEVC104	Hybrid Vehicle Technology	3-0-0	3	50	100	3	-	-
PCC	24PRMC105	Research Methodology and IPR	2-0-0	2	50	100	3	-	-
PCCL	24PEVL106	Electric Vehicle Drives and Control Lab	0-0-2	1	50	-	-	50	3
		Total	**17-0-2**	**18**	**350**	**600**		**50**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for **100 marks** and reduced to **50 marks**

Scheme of Teaching and Examinations – 2025-26
M. Tech. (Electric Vehicle Technology)
II Semester M. Tech.

Course	Course Code	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration in hours
PCC	24PEVC200	Modelling and Simulation of EV	3-2-0	4	50	100	3	-	-
PCC	24PEVC201	Energy Storage Systems and Management	4-0-0	4	50	100	3	-	-
PEC	24PEVEXXX	Elective 1	4-0-0	4	50	100	3	-	-
PEC	24PEVEXXX	Elective 2	4-0-0	4	50	100	3	-	-
PEC	24PEVEXXX	Elective 3	4-0-0	4	50	100	3	-	-
PCCL	24PEVL205	Battery Management System for EV - Simulation Lab	0-0-2	1	50	-	-	50	3
PCCL	24PEVL206	Seminar	0-0-2	1	50	-	-	50	3
	Total		**19-2-4**	**22**	**350**	**500**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

***SEE** for theory courses is conducted for **100 marks** and reduced to **50 marks**.

Mini Project: The students are expected to work individually on a project for the full semester.

Course Code	Elective 1, 2 & 3
24PEVE211	Microcontrollers and Embedded System for EV
24PEVE212	Vehicle Design for E- Power Train
24PEVE213	Artificial Intelligence and Machine Learning
24PEVE214	Computational Methods and Optimization
24PEVE215	Digital Manufacturing and Industry 4.0

I – Semester (Electric Vehicle Technology)

24PEVC100	Applied Mathematics	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

Learn the idea of random variable and probability distribution. To prepare the students to formulate and solve linear programming problem. Study Numerical methods to solve algebraic, transcendental equations. Learn to solve system of linear equations. Introducing students to the fundamental concepts of Graph theory and linear algebra.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Learn the idea of random Variables (discrete/continuous) and probability distributions in analyzing the probability models arising in power system engineering.			1,2
CO-2	Apply the concept of optimization to Solve system of linear and non-linear programming problems.			1,2
CO-3	Learn the Concept of graph theory in engineering problems.			1,2
CO-4	Employ numerical techniques in order to achieve more accurate values in the computation of roots of algebraic and non-linear equations			1,2
CO-5	Apply standard iterative methods to compute Eigen values			1,2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	1.0	1.0		

Prerequisites: Differentiation Matrices, Vectors and Basic Probability Theory

Contents:

1) Probability Theory

Review of basic probability theory. Definitions of random variables and probability distributions, probability mass and density functions, expectation, moments, central moments, characteristic functions, probability generating and moment generating functions-illustrations. Binomial, Poisson, Exponential. **05 Hrs.**

2) Linear and Nonlinear Programming

Simplex Algorithm-Two Phase and Big M techniques– Duality theory-Dual Simplex method. Nonlinear Programming Constrained extremal problems-Lagrange's multiplier method- Kuhn-Tucker conditions and solutions. **10 Hrs.**

3) Graph Theory

Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, shortest path algorithms, applications of graphs. **08 Hrs.**

4) Numerical Methods

Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method (no derivation), Chebyshev method. Fixed point iteration method (first order), acceleration of convergence, Δ - Aitken's method. Bairstow's method. **08 Hrs.**

5) Linear Algebra

Computation of Eigen values and Eigen vectors of real symmetric matrices-Given's method. Orthogonal vectors and orthogonal bases. Gram-Schmidt orthogonalization process. QR decomposition, singular value decomposition**.** **08 Hrs.**

Reference Books:

1) M K Jain, S R K Iyengar, and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2) B. S. Grewal, "Higher Engineering Mathematics", 41st Edition, Khanna Publishers, 2011.
3) Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
4) Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Edition, PHI, 2011.
Richard Bronson, "Schaum's Outlines of Theory and Problems of Matrix Operations", McGraw-Hill, 1988.

24PEVC101 Electric Machines and Drives for EVs (3 - 0 - 0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To enable students to gain knowledge and understanding of fundamentals of power devices and their characteristics.
2. To study the construction, working principle, operation of DC Machine, PMM and its selection for specific applications.
3. To study concepts and operating principles of power convertors.
4. To learn performance parameters of three phase AC motor and its applications.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review and comprehend the concepts of operation of Electrical Machines.	3		
CO-2	Review the concept of DC Machines and its operation and control	3		
CO-3	Explain the concept of operation and control of Permanent Magnet motors.	3		
CO-4	Analyse the performance of AC & DC drives	3		
CO-5	Use speed & torque control strategies of AC drives	3		

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level			3	

Prerequisites: Basics electrical machines principles and Basic electronics.

Contents:

1) Basic Principles of Electrical Machines

Magnetically coupled circuits: review of basic concepts, magnetizing inductance, Modelling linear and nonlinear magnetic circuits Electromechanical

energy conversion: principles of energy flow, concept of field energy and co energy, Derivation of torque expression for various machines using the principles of energy flow and the principle of co energy, Inductance matrices of induction and synchronous machines. **07 Hrs.**

2) Theory Of DC Machines

Review of the DC machine- State-space model of a DC machine- reduced order model & transfer functions of the DC machine. Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control. **08 Hrs.**

3) Permanent magnet motor and Brushless DC Motors

Control Of Permanent Magnet Machine: Power Electronics Control of Permanent magnet synchronous machine, Brushless DC machine, Surface permanent magnet machine and interior. COMPATIBILITY OF MOTOR & DRIVES: Effects of drives on motor - dV/dt, THD, Common Mode Voltage, Shaft Voltage and Bearing Current, Sound & Vibration. **08 Hrs.**

4) AC & DC Drives

Open-loop Dynamic Performance of AC & DC Drives: Starting & reversal time, Energy consumption & energy savings principle. Drives Application Engineering for Fan, Pump, Compressor, Lift-Elevator, Traction application. Synchronization and master-slave configuration, phase controlled dc motor drives, chopper controlled dc motor drives**.** **08 Hrs.**

5) Speed and Torque Control using Drives

AC Drives and its Operational Strategies: Variable frequency operation of three phase induction machine, Scalar control methods for constant power an constant torque modes, Vector control of induction machine, Methods of field sensing and estimation, Field orientation methods: Implementation of IRFO scheme using current controlled PWM, VSI and implementation of DSFO scheme using CSI, Performance of vector controlled permanent magnet machine. **08 Hrs.**

Reference Books:

1) G. K. Dubey, Power Semiconductor controlled Drives, New Age Int. Pub.
2) R. Krishnan, Electric Motor drives – Modelling, Analysis & Control:, PHI India, Ltd.
3) R. Krishnan, ‘Electric motor drives’, Prentice hall of India, 2002.
4) T. Kenjo and S. Nagamori, ‘Permanent magnet and Brushless DC motors’, Clarendon press, London, 1988.
5) P. S. Bhimbra, “The Generalized Theory of Electrical Machines”, Tata McGraw Hill
6) B. Adkins and R. G. Harley, “The General theory of AC Machines”, Tata McGraw Hill

7) R. Krishnan, “Electric Motor Drives – Modelling, Analysis and Control”, PHI.
8) T. J. E. Miller, “Brushless magnet and Reluctance motor drives”, Claredon press, London, 1989.
9) R. Krishnan, “Switched Reluctance motor drives”, CRC press, 2001.
10) T. Kenjo, ‘Stepping motors and their microprocessor controls’, Oxford University press, New Delhi, 2000.

24PEVC102 Automotive Technology (3 - 0 - 0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

The course focuses on Electronic Engine control system, construction and operation of sensors and actuators, role of electronics in vehicle motion control, instrumentation and advanced features for safety and comfort in vehicles.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain various parts and operation of automobile system, electronic control system and microcomputer system.			4
CO-2	Explain and apply control system approach to Engine control and define various performance parameters.		1	4
CO-3	Describe the construction and operation of various sensors and actuators used in automotive control applications.	4		
CO-4	Analyze and Explain vehicle motion control system and automotive instrumentation systems.	4	3	
CO-5	Describe various advanced electronic features, communication protocols and diagnostics	4	1	3

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	2.0	-	1.5	2.2

Pre-requisites:

Basics of Automobiles and Engines, Analog and Digital Electronic Circuits, Control systems and Microcontrollers.

Contents:

1) **Automotive Fundamentals:** Evolution of Automotive Electronics, Automobile Physical configuration, SI Engine and its operation, Engine control, Ignition system, Diesel Engine, Hybrid vehicle configuration, Drive Train, Brakes, Suspension, Steering System. Control System Approach: Open loop and closed loop control systems, Proportional Controller, Proportional-Integral controller, Closed Loop Limit Cycle control. Microcomputer Systems: Microcontroller applications in automotive systems, Instrumentation applications of microcomputers, Microcomputers in control systems. **10 Hrs.**
2) **Basics of Electronic Engine Control:** Motivation for electronic engine control, Government Test procedures, Concept of an electronic engine control system, Definition of General Terms and Engine performance terms, Engine Mapping, Control Strategy, Electronic fuel control system, Analysis of intake manifold pressure, Idle speed control, Electronic Ignition. **08 Hrs.**
3) **Sensors and Actuators:** Control system applications of sensors and actuators, Airflow rate sensors, Engine Crankshaft angular position sensors, Throttle angle sensor, Temperature Sensors, Sensors for feedback control, Knock sensors, Engine control actuators, variable valve Timing. **08 Hrs.**
4) **Electric Vehicle Motion Control:** Typical Cruise control system, Cruise control electronics, Antilock braking System, Electronically controlled Suspension system, Electronic steering control. Automotive Instrumentation: Modern Automotive Instrumentation, Input and Output Signal Conversion, Sampling, Fuel Quantity measurement, Coolant Temperature measurement, Oil Pressure measurement, Vehicle Speed measurement**.** **08 Hrs.**
5) **Advanced Automotive Electronic Systems:** Occupant Protection Systems, Collision avoidance RADAR warning system, Low Tyre-pressure warning system, Sensor and Control Signal Multiplexing, Navigation. Communication Protocols: CAN protocol, LIN protocol. **05 Hrs.**

Reference Books:

1) William B. Ribbens, "Understanding Automotive Electronics", 6/e, Newnes, 2003.

2) A. K. Babu, “Automotive Electrical and Electronics”, 2/e, Khanna publishing,2016
3) Tom Denton, “Automobile Electrical and Electronic Systems”, 5/e, Institute off Motor Industry, 2017
4) Najamuz Zaman, “Automotive Electronics Design Fundamental’’ First Edition, Springer 2015.

24PEVC103 Electric Vehicle Dynamics and Aerodynamics (3 - 0 -0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To enable students to gain knowledge and understanding of fundamentals of vehicle dynamics.
2. To study the ADAS, Autonomous driving concepts.
3. To study concepts of longitudinal, vertical and lateral dynamics.
4. To learn the concepts of aerodynamics.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 4)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the definitions of vehicle dynamics and different types of vehicles.	--	--	1
CO-2	Comprehend the vehicle interactions especially with tyres.	--	3	--
CO-3	Analyze the dynamic concepts in relation to the longitudinal, lateral and vertical dynamics.	--	--	4
CO-4	Demonstrate the concepts of aerodynamics	--	--	1

POs	PO-1	PO-2	PO-3	PO-4
Mapping Level	1	--	2	1

Prerequisites: Mechanical Vibrations.

Contents:

1) **Introduction:** Definition of vehicle dynamics, ADAS, Autonomous driving, simulation tools, MBS tools, light and heavy duty vehicles. **06 Hrs.**

2) **Vehicle Interactions:** Introduction, tyre terminology, tyre design, longitudinal, lateral and vertical properties of tyres, tyre wear, driver interactions with vehicle dynamics. **07 Hrs.**
3) **Longitudinal dynamics:** Introduction, steady state functions, functions over longer events, functions in shorter events, control functions. **08 Hrs.**
4) **Lateral dynamics:** Introduction, low speed maneuverability, steady state cornering at high speed, stationary steady oscillating steering, transient handling, lateral control functions. **08 Hrs.**
5) **Vertical dynamics:** Introduction, suspension system, road models, 1-D vehicle models, ride comfort, fatigue life, road grip, variation of suspension design, 2-D oscillations. **08 Hrs.**
6) **Vehicle aerodynamics:** Introduction, longitudinal wind velocity, lateral wind velocity **02 Hrs.**

Reference Books:

1) Bengt Jacobson, “Vehicle Dynamics” Chalmers University of Technology, Sweden, 2016.
2) Wong J.Y., “Theory of Ground Vehicles”, John Wiley and Sons, Inc., New York, 2001.
3) Gillespie T., Fundamentals of vehicle dynamics, SAE, 1992.

24PEVC104 Hybrid Vehicle Technology (3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

The objectives of this course are to make the student to learn:

1. Basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2. Plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3. The analysis of various electric drives suitable for hybrid electric vehicles.
4. Different energy storage technologies used for hybrid electric vehicles and their control.
5. Different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management

Course outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain working of IC engines and factors affecting the combustion	1	-	2
CO-2	Discuss different configurations of electric and hybrid vehicles and their parts.	3	-	-
CO-3	Describe various aspects of hybrid and electric vehicle drive trains	3	-	-
CO-4	Discuss different energy storage technologies, sizing of drive system and pollution control	3	-	-

POs	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	3.0	1.0	3.0	-

Prerequisites: IC Engine, Automobile engineering, and Basics of Electrical Engineering.

Contents:

1) **Conventional Vehicles:** Introduction to conventional internal combustion engines, Basics of vehicle performance, vehicle power source, Power transmission, Fuel economy characteristics of internal combustion engine. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, Merits and demerits of electric and hybrid vehicles. **08 Hrs.**
2) **Basic concept of Electrical and Hybrid vehicles:** Hybrid traction, introduction to various hybrid drive-train topologies, Vehicle power plant and transmission characteristics and vehicle performance including braking performance. Basic architecture of hybrid drive train and analysis series drive train. Analysis of parallel, series parallel and complex drive trains and power flow in each case. Basic concept of electric traction and architecture. Topologies for electric drive-train and their analysis, power flow control in electric drive-train topologies. **08 Hrs.**
3) **Electric Propulsion Systems:** Components used in hybrid and electric vehicles, Electric drives used in HEV/EVs, their classifications and general

characteristics. Induction motors, their configurations and optimization for HEV/EVs. Induction motor drives, their control and applications in EV/HEVs. DC Motor drives and their principle of operation and performance including multi-quadrant control. Permanent magnet motors, their configurations and optimization. Permanent magnet motor drives, their control and applications in EV/HEVs. Configuration and control of DC and Induction Motor drives. **08 Hrs.**

4) **Energy Storage:** Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis and simplified models of battery. Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. **07 Hrs.**
5) **Sizing the drive system:** Matching the electric drive and ICE, Transmission selection and gear step selection. Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology. Air pollution and global warming: social and environmental importance of hybrid and electric vehicles, Impact of different transportation technologies on environment and energy supply. **08 Hrs.**

Reference Books:

1) James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 2003.
2) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2004.
3) Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2003.
4) R1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
5) Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000.
6) John B Heywood, “IC Engine Fundamentals”, International Editions, Automobile Technology Series, McGraw hill, 2010.
7) M. L. Mathur and R. P. Sharma, “I. C. Engines”, Dhanpat Rai & Sons, New Delhi, 2011.

24PRMC105	Research Methodology and IPR	(2 - 0 - 0) 2

Contact Hours: 26

Course Learning Objectives (CLOs):

The students are expected to learn about the needs and types of research, problem formulation, literature review, measurement, scaling, data collection, testing of hypothesis, result interpretation, and report writing. Further, the students shall know about intellectual property rights, copyrights, trademarks, patents,

patent filing procedures, infringement & remedies, and the Information Technology Act, etc.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course, the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Formulate their search problem, carryout literature survey and decide the methodology.		1	
CO-2	Use measurement and scaling and carryout data collection.		1	
CO-3	Test the hypothesis, interpret & analyze the results, and write the report.	2	3	
CO-4	Explain the need of IPR, copy right, patents, trademarks, & the filing procedure and know about infringement, remedies, and regulatory framework.		2	

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	2.0	2.5	2.0	--

Contents:

1) **Research Methodology:** Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, research process, criteria of good research and problems encountered by researchers in India.
   Defining the Research Problem: Research problem, selecting the problem, technique involved in defining a problem, an illustration. **04 Hrs.**
2) **Reviewing the literature:** How to review the literature, searching the existing literature, reviewing the selected literature.
   Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design, different research designs. **04 Hrs.**
3) **Measurement and Scaling:** Measurement in research, measurement scales, sources of error in measurement.

Data Collection: Collection of primary data, collection of secondary data.

04 Hrs.

4) **Testing of Hypotheses:** What is a Hypothesis? Basic concepts concerning testing of hypotheses, procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, tests of hypotheses. **04 Hrs.**
5) **Interpretation and Report Writing:** Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing, different steps in writing report, layout of the research report, precautions for writing research reports, plagiarism and its significance. **03 Hrs.**
6) **Introduction to Intellectual Property Rights:** Meaning and conception of IPR, competing, rationale for protection, international conventions, world court.

Copy right: Meaning, content, substance, ownership, primary, special rights, obligations, period, assignment, and relinquishment of copyrights. License and application for registration of copyright.

Patents: Meaning of Patent, purpose and policy object of patent law, gains to the inventor, application of patents, joint application, discovery and invention, patentable and non-patentable inventions. .

Industrial design: Concepts & Significance

Trademarks: Definitions and conceptions of Trademark, advantages of registration, marks which are not registrable, known, and well-known trademarks, application for registration and procedure for registration, procedure, and certification of Trademarks.

Infringement and Remedies: Meaning of infringement, acts of infringement.

07 Hrs.

Self-Study-

The Information Technology Act: Definitions, certifying authority, meaning of compromise of digital signature, offences and penalties, the applicability of IPRs, cybercrimes, adjudicating officer, violation, damages and penalties, Cyber regulation appellate tribunal, World Wide Web and domain names and cyber flying.

Reference Books:

1) C.R. Kothari, Gaurav Garg, Research Methodology: Methods and Techniques, New Age International, 4th Edition, 2018.
2) Ranjit Kumar, Research Methodology a step-by-step guide for beginners, SAGE Publications, 3rd Edition, 2011.
3) Fink A, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
4) N. K. Acharya, “Textbook on Intellectual Property Rights”, 4th Edition, Asia Law House, Hyderabad.

22PEVL106 Electric Vehicle Drives and Control Lab (0 - 0 - 2) 1

Contact Hours: 26

Course Learning Objectives:

1) Conduct experiments to study the performance characteristics of electrical and mechanical drives.
2) Conduct experiments on various control schemes for drives control.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the knowledge of engineering to conduct different experiments on drives.	4	1,3	2
CO-2	Apply the knowledge of engineering to conduct different experiments on control schemes applied to drives control.	4	1,3	2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	2.0	1.0	2.0	3.0

List of Experiments:

(Minimum 10 Experiments are to be conducted)

1. Performance evaluation of DC drives used in EVs.
2. Study of effect of duty cycle on temperature variation in DC motors.
3. Close loop speed control of DC drives and verification using simulation.
4. Speed control of 3 phase induction motor using IGBT converter.
5. Demonstration of reversal of direction of rotation of BLDC motor.
6. Load test on EV drive system.
7. Evaluate the influence of engine variable on the performance of IC engine
8. Demonstration of various elements of transmission system (clutch, differentials, gearbox etc.)
9. Calculate and compare the brake power torque and mechanical efficiency of IC engine and electric motor of same capacity.
10. Demonstration of mechanical braking system.
11. Switching characteristics of i) SCR ii) IGBT.
12. Single phase full controlled bridge converter with R and R-L load.
13. DC to single/three phase AC conversion with R and R-L loads.

II – Semester (Electric Vehicle Technology)

24PEVC200	Modelling and Simulation of EV	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The Students are expected to learn:

1. Interlinking performance parameters of sub-systems of EV
2. Analysis of vehicle resistances and Battery parameters.
3. Performance analysis of Drivetrain components
4. Vehicular level performance analysis and simulation

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Model various subsystems of EV		2	
CO-2	Model Vehicle Resistances and Battery pack		2	
CO-3	Analysis Electric & Hybrid Electric Vehicles Propulsion and power train components	3		
CO-4	Analyse Energy Flow and its management	3		
CO-5	Model & Simulate vehicular parameters		2	

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level		**3**	**2**	

Prerequisites: Fundamentals of EV, Vehicle Technology, MATLAB/Simulink, RICARDO

Contents:

1) Vehicular sub-systems Modelling

Modelling of sub-systems - Battery, Motor, Vehicle Body, Drive cycles input Performance outputs. **8L+2T Hrs.**

2) Modelling of Vehicle Resistances and Battery Pack

Electric Vehicle Modelling - Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort,

Modelling Electric Vehicle Range -Driving cycles, Range modelling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles **8L+2T Hrs.**

3) Drivetrain Characteristics

Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics, Electric Motor Performance Characteristics - Battery Performance Characteristics Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles. Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis. **8L+2T Hrs.**

4) Energy Flow analysis

Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers – Rule-Based Control Strategies -Optimization-Based Control Strategies. **8L+2T Hrs.**

5) Vehicular Parameter Modelling and Simulation

Modelling Vehicle performance parameters, Simulation of the speed, acceleration, range of an electric scooter, Simulation of the speed, acceleration, range of a small car. Simulation for weight reduction. **10L+2T Hrs.**

Reference Books:

1) Amir Khajepour, Saber Fallah and Avesta Goodarzi, “Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach”, John Wiley & Sons Ltd, 2014.
2) Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles_ Fundamentals, Theory, and Design, Second Edition”, CRC Press, 2010.
3) Tutorials on MATLAB /SIMULINK for modelling and simulation.
4) Tutorials on RICARDO for modelling and simulation.

24PEVC201 Energy Storage Systems and Management (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

The students are expected to learn about the requirements of energy storage in the hybrid electric vehicle, the type of energy storage systems used and the chargers. The students are also expected to learn the aspects of energy management and various battery management systems as applicable to electric vehicles.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1 to 4)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Analyze the different types of storage systems applicable to electric vehicles		3	
CO-2	Comprehend the modelling of different types of batteries and fuel cells applicable to electric vehicles		3	
CO-3	Explain the energy management strategies used in hybrid electric vehicles		3	
CO-4	Design and test various battery management schemes applied to hybrid electric vehicles		3	1
CO-5	Choose different types of chargers in hybrid electric vehicles.		3	

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	1.0	-	2.0	-

Prerequisites: Basics of energy storage.

Contents:

1) **Introduction**: Energy Storage Requirements in Hybrid and Electric Vehicles, Battery-based energy storage and its analysis, Fuel Cell-based energy storage and its analysis, Super Capacitor-based energy storage and its analysis, Flywheel-based energy storage and its analysis, Hybridization of different energy storage devices**.** **10 Hrs.**
2) **Types of batteries –** Lead Acid, Li-ion, Li-Po, Metal-Air batteries, etc., Architecture: Cell, Modules, and Pack, Battery charging and discharging cycles, Use of batteries in the hybrid powertrain, Mathematical Modelling for Li-ion battery, Solid State Battery, Fuel cell, Issues in the fuel cell, Hydrogen fuel cell, Fuel cell thermodynamics, Main reasons for the loss in voltage. **10 Hrs.**
3) **Energy management:** Strategies used in hybrid and electric vehicles**,** classification of different energy management strategies, comparison of different energy management strategies, and implementation issues of energy

management strategies. **10 Hrs.**

4) **Battery Management System (BMS):** Types of BMS, functions of BMS, State of Charge (SoC), and State of health (SoH) estimations. BMS Functionalities, Design, and model battery systems Parameterize equivalent circuit battery models using experimental I, V, T data, BMS testing **10 Hrs.**

   Simulation of BMS (Self-study component) **02 Hrs.**

5) **Types of Chargers: -** AC/DC, Slow/Fast, Types of connectors: - GBT, CCS, Chademo, Communication protocol, OCPP 1.6, Electronic details, Chargers Rating. **Charging stations:** Types of charging stations and effect on distribution network. **10 Hrs.**

Reference Books:

1) Energy Storage Systems and Components Alfred Rufer - -CRC Press (2018)
2) Hybrid Electric Vehicles_ Energy Management Strategies-Springer-Verlag London (2016)
3) Battery management systems for large lithium battery packs by Andrea, Davide (z-lib.org)

24PEVE211 Microcontrollers and Embedded Systems for EV (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

The course aims at having fundamental understanding of Microprocessor and Controller architectures. It also exposes the variety of peripherals and the way they must be interfaced with the processors/controllers. Communication standards used in automotive industry are also stressed upon in this course. Programming to accomplish the functionality with the usage of IDE, SDK/EDK s are also being explored. The course also targets to Testing procedures and processes which are integral part of design and development. These aspects of Microcontrollers and embedded Systems are studied with the prospect of EV.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discover the different Microprocessor/ Controller Architectures and can choose appropriate architecture for the	1,2,4	3	

	given application			
CO-2	Interface different peripheral devices and memory.	2	1,3	4
CO-3	Design Program and Evaluate the functionality at different levels.	4	3	2
CO-4	Compare and follow Embedded Communication Standards.		3,4	
CO-5	Discuss and apply the test processes and planning		3,4	1,2

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	2	2	2	2.2

Prerequisites: Basics of Analog and Digital Electronics

Contents:

1) **Introduction:** General Processor Architecture Microprocessors and Controllers (PIC, AVR and ARM), ARM Processor Fundamentals, ARM and THUMB Instruction Set. **10 Hrs.**
2) **Memory-Mapped Peripherals**: UART, D/A converter, Configuring GPIOS, Keyboard, LED, LCD Interfacing **10 Hrs.**
3) **Efficient Programming Overview of C Compilers and Optimization** :Basic C Data Types, C Looping ,Structures , Register Allocation, Function Calls, Pointer Aliasing, Structure Arrangement, Bit-fields, Unaligned Data and Endianness , Division, Floating Point ,Inline Functions and Inline Assembly, Portability Issues, Writing Assembly Code , Profiling and Cycle Counting , Instruction Scheduling , Register Allocation , Conditional Execution, Looping Constructs, Bit Manipulation, Efficient Switches, Handling Unaligned Data. **10 Hrs.**
4) **Embedded Communication Standards in Automotive Communication Systems:** Characteristics and Constraints ,In- Car Embedded Networks ,Middleware Layer, Open Issues for Automotive Communication Systems, Flex Ray Communication, Flex Ray Protocol , Flex Ray Application; Data Consistency Issues, CAN centrate and Re CAN centrate: Star Topologies for CAN , CANEL y ,FTT-CAN: Flexible Time-Triggered Communication on CAN , Flex CAN: A Deterministic, Flexible, and Dependable Architecture for Automotive Networks , Other Approaches to Dependability in CAN. **12 Hrs.**

5) Testing: Dynamic Testing, Current Practice, Structuring the Testing Process, Model versus Code-Based Testing, Test Activities and Testing Techniques, Testing in the Development Process, Test Planning **10 Hrs.**

Reference Books:

1) Andrew N. Sloss "ARM System Developer's Guide Designing and Optimizing System Software", Elsevier Inc., ISBN :1-55860-874-5
2) William Hohl, "ARM Assembly Language Fundamentals and techniques", Springer, ISBN 13: 978-1-4822-2986-8
3) Richard Zurawski, "Automotive Embedded Systems Handbook", CRC Press, ISBN 13: 978-0-8493-8026-6
4) M. Kathiresh, R. Neelaveni, "Automotive Embedded Systems: Key Technologies, Innovations, and Applications", Springer, ISBN: 978-3-030-59896-9

24PEVE212 Vehicle Design for E- Power Train (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To enable students to gain knowledge and understanding of fundamentals road loss coefficient also power, energy and speed relationship of electric vehicle.
2. To study the operating principles of automatic and semiautomatic transmission.
3. To understand electric drive-train topologies and power flows in drive train.
4. To learn to control different motors and sizing of different subsystems of electric vehicle.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Recite fundamentals of road loss coefficients, power, energy and speed relationship of electric vehicle	3		
CO-2	Explain principle and working of semi-automatic & automatic transmission	3		
CO-3	Explain power flow in different drive-train topologies	3		

CO-4	Comprehend configuration and control of different propulsion units.	3		
CO-5	Explain sizing and design of HEV & BEV	3		

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level			3	

Prerequisites: Electric Machines and Power Electronics

Contents:

1) **E- Power**

Vehicle Load forces, Basic power, Energy and Speed relationships, Aerodynamic drag, Rolling resistance, Vehicle Road- Loss coefficients, Battery electric vehicle range at a constant speed, Gradeability, Vehicle acceleration, Regenerative braking of the vehicle, Simple drive cycle for the vehicle. **10 Hrs.**

2) **Automatic Transmission**

Principle of semi-automatic & automatic transmission, Hydramatic transmission, Fully automatic transmission, Semi-automatic transmission, Hydraulic control system, Continuous variable transmission (CVT) – operating principle, basic layout, and operation, Advantages, and disadvantages. **11 Hrs.**

3) **Drive Train**

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, efficiency analysis **10 Hrs.**

4) **Electric Propulsion unit**

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration, and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration, and control of Switch Reluctance Motor drives, drive system efficiency. **11 Hrs.**

5) **Sizing of Electric Vehicle system**

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV). **10 Hrs.**

Reference Books:

1) Electric powertrain energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles Goodarzi, Gordon A. Hayes, John G - John Wiley & Sons (2018)
2) Automotive power transmission systems Mi, Chris Zhang, Yi - (2018, John Wiley & Sons Ltd)
3) Hybrid Electric Power Train Engineering and Technology Modelling, Control, and Simulation-IGI Global (2013) Antoni Szymanowski.

24PEVE213 Artificial Intelligence and Machine Learning (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

The course focuses on the fundamental concepts in artificial intelligence &machine learning. Topics covered include linear modelling, Bayesian approach, classification, clustering and popular machine learning algorithms in each topic. The course also discusses various issues related to the application of artificial intelligence using machine learning techniques.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 6)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Recognize the characteristics of artificial intelligence systems that make it useful to real-world problems	-	3,1	2
CO-2	Analyze the situations of applying variety of mathematical models and algorithms for machine learning	3	1	-
CO-3	Compare and justify various mathematical models and algorithms used in machine learning	4,1	3	2
CO-4	Justify the selection of various classification and regression supervised/unsupervised learning problems of machine learning	-	3,1	-

CO-5	Select and implement machine learning techniques that are suitable for the applications under consideration	4	3,1	-
CO-6	Evaluate the performance of various machine learning algorithms	-	3	1

PO's	PO-1	PO-2	PO-3	PO-4
Mapping Level	2.0	1.0	2.2	3.0

Pre-requisites: Basics of probability and statistics, Linear algebra

Contents:

1) **Introduction to Artificial Intelligence:** History of artificial intelligence, Propositional logic; basics of propositional logic, Resolution, Artificial intelligence applications, First order logic; basics of first order logic, certain knowledge representation; Taxonomic knowledge, Frames, Nonmonotonic logic. **08 Hrs.**
2) **Linear Modelling-A Least Squares Approach:** Linear Modelling, Making Predictions, Vector/Matrix Notation, Non-Linear Response from a Linear Model, Generalization and Over-Fitting, Regularized Least Squares. **08 Hrs.**
3) **Linear Modelling-A Maximum Likelihood Approach:** Errors as Noise, Random Variables and Probability, Popular Discrete Distributions, Continuous Random Variables - Density Functions, Popular Continuous Density Functions, Likelihood, The Bias-Variance Trade-off, Effect of Noise on Parameter Estimates, Variability in Predictions. **08 Hrs.**
4) **The Bayesian Approach to Machine Learning**: A Coin Game, Exact Posterior, The Three Scenarios, Marginal Likelihoods, Hyper parameters, Graphical Models, A Bayesian Treatment of the Olympic100m Data, Marginal Likelihood for Polynomial Model Order Selection. **08 Hrs.**
5) **Bayesian Inference:** Non-Conjugate Models, Binary Responses, A Point Estimate - The Map Solution, The Laplace Approximation, Sampling Techniques. **08 Hrs.**
6) **Classification:** The General Problem, Probabilistic Classifiers, Non-Probabilistic Classifiers, Assessing Classification Performance, Discriminative and Generative Classifiers. **08 Hrs.**
7) **Clustering:** The General Problem, K-Means Clustering, Mixture Models.**04 Hrs.**

Activity beyond Syllabus: Program development for the machine learning Algorithms in MATLAB/ Python.

Reference Books:

1) Simon Rogers, Mark Girolami, "A First Course in Machine Learning", second edition, CRC Press, 2017.
2) Richard E. Neapolitan & xia Jiang, "Artificial Intelligence with an introduction to machine learning", second edition, CRC press, 2018.
3) Ethem Alpaydin, "Introduction to Machine Learning", Prentice Hall of India, Third edition, 2014.
4) Mohssen Mohammed, Muhammad Badruddin Khan, Eihab Bashier Mohammed Bashier, "Machine Learning, Algorithms and Applications", CRC Press, 2017.
5) Michael Paluszek, Stephanie Thomas, "MATLAB Machine Learning", A press, 2017.

24PEVE214 Computational Methods and Optimization (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The course focuses on key criteria: area, speed, optimization techniques employed, various system architectures considered in the FPGA method of Design.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-6)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate the basics of Computational methods and optimization Algorithm.	-	3	-
CO-2	Explain Surrogate based optimization techniques	3	4	1
CO-3	Demonstrate local and global optimization techniques in derivative optimization techniques	3	4	-
CO-4	Model Maximum Simulated Likelihood Estimation techniques	-	4	-
CO-5	Demonstrate Particle Swarm Optimization techniques	4	-	-

CO-6	Model of Traditional and Hybrid Derivative-Free Optimization Approaches for Black Box Functions	-	-	-

POs	PO-1	PO-2	PO-3	PO-4
Mapping Level	1	-	2.66	2.25

Contents:

1) **Computational Optimization**: An Overview, Introduction, Computational Optimization, Optimization Procedure, Optimizer, Simulator, Latest Developments. **08 Hrs.**
2) **Optimization Algorithms**: Introduction, Derivative-Based Algorithms, Derivative-Free Algorithms, Metaheuristic Algorithms, Unified Approach to Metaheuristics, Generalized Evolutionary Walk Algorithm. **08 Hrs.**
3) **Surrogate-Based Methods**: Introduction, Surrogate-Based Optimization, Surrogate Models, Surrogate-Based Optimization Techniques, Remarks. **08 Hrs.**
4) **Derivative-Free Optimization**: Introduction, Derivative-Free Optimization, Local Optimization, Global Optimization, Guidelines for Generally Constrained Optimization, Remarks. **08 Hrs.**
5) **Maximum Simulated Likelihood Estimation**: Techniques and Applications in Economics: Introduction, Copula Model, Estimation Methodology, Application, Remarks. **08 Hrs.**
6) **Optimizing Complex Multi-location Inventory Models Using Particle Swarm Optimization**: Introduction, Simulation Optimization, Multi-Location Inventory Models with Lateral Transhipments, Particle Swarm Optimization . **07 Hrs.**
7) **Traditional and Hybrid Derivative-Free Optimization Approaches for Black Box Functions**: Introduction and Motivation, A Motivating Example, Traditional Derivative-Free Optimization Methods, DFO Hybrids. **05 Hrs.**

Reference Books:

1) Slawomir Koziel and Xin-She Yang, “Computational Optimization, Methods and Algorithm”, Springer, 2011.
2) M Sarfaraz and Samsul, “Computational Optimization Techniques and Applications, 2021.
3) Mario Koppan, Gerald and Ajit, “Intelligent Computational Optimization in Engineering”, Springer.

24PEVE215 Digital Manufacturing and Industry 4.0 (4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs): The students are expected to learn:

1. The concepts of drivers and enablers of Industry 4.0
2. To appreciate the smartness in Smart Factories, smart products and smart services
3. To outline the various systems used in a digital manufacturing plant and their role in an Industry 4.0 world
4. To appreciate the power of Rapid Prototyping in current industrial scenario
5. To know the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to obtain the benefits

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the principle and application of 3D Scanning Techniques.	--	--	1
CO-2	Discuss the application of CAD modelling, Direct Digital Manufacturing and Rapid Prototyping Techniques.	--	--	1
CO-3	Explain the main concepts, technologies and components of Industry 4.0	--	--	1
CO-4	Recognize recent technological components of robots	--	--	1,4
CO-5	Discuss the role of augmented Reality in the age of Industry 4.0 and distinguish the obstacles in achieving Industry 4.0.	--	--	1,4

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	1	--	--	1

Prerequisites: Basic of CAD/CAM, 3D Printing, Manufacturing and Robotics

Contents:

1) **Introduction to Direct Digital Manufacturing Technologies:** Stereo lithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM), "3DP" and printed liquid binders, Printed polymers, Computer Numerical Control (CNC) machining. **10 Hrs.**
2) **Modelling Techniques for 3D Output:** Design for Direct Digital Manufacturing Design for manufacturing and assembly, Design tools Production planning and control **10 Hrs.**
3) **Post-processing of Direct Digital Manufactured Components:** Surface texture improvement, Property enhancements, Cost estimation Applications. **08 Hrs.**
4) **Introduction to Industry 4.0:** Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Industry 4.0 production system, current state of industry 4.0, Technologies, how is India preparing for Industry 4.0, A Conceptual Framework for Industry 4.0: Introduction, Main Concepts and Components of Industry 4.0, State of Art, Supportive Technologies, Proposed Framework for Industry 4.0. **12 Hrs.**
5) **The Role of Augmented Reality in the Age of Industry 4.0:** Introduction, AR Hardware and Software Technology, Industrial Applications of AR. Obstacles and Framework Conditions for Industry 4.0 Lack of A Digital Strategy alongside Resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers, comprehensive broadband infra-structure, state support, legal framework, protection of corporate data, liability, handling personal data **12 Hrs.**

Reference Books:

1) “Digital Manufacturing and Assembly Systems in Industry 4.0”, 1st Edition, by Kaushik Kumar, Divya Zindani, J. Paulo Davim, 2020.
2) “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing”, Andreas Gebhardt, Hanser Publisher, 2011.
3) “Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing”, Lan Gibson, David W. Rosen and Brent Stucker, Springer, 2010.

24PEVL205 Battery Management System for EV - Simulation Lab (0-0-2)1

Contact Hours: 26

Course Learning Objectives:

1) Conduct experiments to study the performance characteristics of various batteries used in electric vehicles.

2) Carryout simulation study to know the performance characteristics of various batteries used in electric vehicles.
3) Carryout simulation of EV system.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the performance characteristics of various batteries used in electric vehicles.	4	1,3	2
CO-2	Simulate to know the performance characteristics of various batteries used in electric vehicles.	4	1,3	2
CO-3	Carryout simulation of EV system to know the performance.	4	1,3	2

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	2.0	1.0	2.0	3.0

List of Experiments: Minimum 10 Experiments are to be conducted

1. Study of construction of various batteries.
2. Determination of performance of modular structure battery.
3. Simulation of electrical energy storage components.
4. Simulation of battery management system using suitable software.
5. Mechanical aspects of maintenance of batteries.
6. Determination of thermal conductivity of composite materials.
7. Performance evaluation of electrical vehicle chassis using models.
8. Study of wiring layout of electric vehicle.
9. Simulation of Prototype EV using MATLAB/SIMULINK
10. Comprehensive functionality of instrumentation using LABVIEW.
11. Implementation of automotive applications using MICROCONTROLLER
12. MOSFET based step up and step-down chopper.

Reference Materials: Lab manual

24PEVL206	Seminar	(0-0-2)1

Contact Hours: 26

Course Learning Objectives (CLOs):

The objective of the seminar is to inculcate self-learning, enhance communication skill, involve in group discussion and present the ideas before the audience. The topic of seminar to be selected by the student shall be helpful to the community/society.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1 to 4)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Communicate effectively on a technical topic related to the programme.	1, 3	2	4
CO-2	Present technical information through self-learning.	1, 3	2	4
CO-3	Involve in technical interaction actively.	1, 3	2	4
CO-4	Justify the concepts presented during question answer session and make a way for helping the community /society.	1, 3	2	4

PO's	**PO-1**	**PO-2**	**PO-3**	**PO-4**
Mapping Level	3.0	2.0	3.0	1.0

Each student, under the guidance of a faculty, is required to,

i) Choose a topic of his/her interest relevant to the Course of Specialization.

ii) Carryout literature survey, organize the subject topics in a systematic order

iii) Prepare the report with own sentences.

iv) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.

v) Present the seminar topic at least for 40 minutes through power point slides.

vi) Answer the queries and involve in debate/discussion lasting for about 10 minutes

vii) Submit two copies of the typed report with a list of references.

ix) The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. The internal assessment marks shall be awarded by a committee consisting of at least two staff members based on the relevance of the topic, presentation skill, participation in the question & answer session and quality of report.