B.Tech - Electrical& Electronics Engineering (EVT)
Semester-IV

L-3 T-1 P-0 C-4

PCEEE0400A: Electromagnetic Field Theory

Course Objectives

- To learn principles and basics of vector algebra and different coordinate systems
- To understand the details of the basic laws and applications of electric fields
- To define and understand the basics of magnetic fields
- To analyze of time varying behavior of electromagnetic waves
- To examine the behavior of electromagnetic waves in different mediums and their applications

Course Outcomes (COs)

1. Remember aboutthe basics of vector algebra and its application in EM fields
2. Understandthe working of electrostatic fields by physical interpretation of various laws
3. Apply the laws of magnetism to different applicable field
4. Analyze the working of time varying fields
5. Evaluate the behavior of Reflection and refraction of plane waves

Articulation Matrix

(Program Articulation Matrix is formed by the strength of correlation of COs with POs and PSOs. The strength of correlation is indicated as 3 for substantial (high), 2 for moderate (medium) correlation, and 1 for slight (low) correlation)

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	1	-	-	1
CO2	1	3	2	-	-	-	-	-	-	-	-	1	1	-	-
CO3	1	2	3	-	1	-	-	-	-	-	-	1	-	-	1
CO4	1	2	3	2	-	-	-	-	-	-	-	1	-	1	1
CO5	1	2	2	1	1	-	-	-	-	-	-	1	2	1	1

High-3 Medium-2 Low-1

Unit I Vector Analysis — 12 Hours

Scalars and Vectors, Vector Algebra, Rectangular Coordinate System, Vector Components and Unit Vectors, Vector Field, Dot Product, Cross Product, Other Coordinate Systems: Circular, Cylindrical Coordinates & Spherical Coordinate System

Unit II Static Electric Fields — 12 Hours

Columb's law, electric flux density and electric field intensity, permittivity, potential function, Gauss's law, Potential gradient, dielectrics and capacitance, Laplace's and Poisson's equations, Uniqueness theorem, Examples of solution of Laplace'sequation,Electric dipole, stored electric energy density. Boundaryconditions at abrupt discontinuities between two media including conducting boundaries

Unit III Static Current and Magnetic Field — 12 Hours

Current and current density, Continuity of current, Conductor properties and boundary conditions, specific conductivity, mobility, explanation of Ohm's law employing mobility, Bio-Savart law, Ampere's circuit law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials. Force on a moving charge, Force between differential current elements, Force and torque on a closed circuit, Magnetization and permeability, Magnetic boundary conditions, Problems related to straight wire toroidal, inductance

Unit IV Time Varying Fields — 12 Hours

Faraday's law in integral and differential forms, displacement currentconcept, Maxwell's equations in differential and integral forms, wave equations in source freeregion electric and magnetic stored energy density, continuity equation, Poynting vectortheorem. Maxwell's equations for TH field

Unit V Reflection and refraction of plane waves **12 Hours**

Plane waves in lossy medium, low loss dielectric, good conducting and ionized media, complexPermittivity, Brewster's angle, total internal reflection phase velocity and group velocity. Magnetic vector potential for sources in free space, retarded potential

Total: 60 Hours

Reference(s)

1. Mathew N.O Sadiku (2022), Elements of Electromagnetic, Oxford University Press
2. William H. Hayt(2017), Engineering Electromagnetic, Tata McGraw Hills
3. John D. Kraus (2017), Electromagnetic, Tata McGraw Hills

List of e-Learning Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ee83
2. https://www.udemy.com/course/crash-course-on-electromagnetic-field-theory-emft

Subject Expert	Academic Coordinator	HoD	Appointed Senior Faculty by DoAA

MandsaurUniversity

B.Tech.Electrical and Electronics Engineering (EVT)

Semester-IV

L-2, T-1, P-2, C-4

EEE270: Electrical Machine-II

Course Objectives

- To remember basics of DC machines and fundamental concepts of cause and cure of armature reaction in DC machines
- To understand the operations of DC machines and performing of tests on DC motors for efficiency calculations
- To apply basics fundamental of synchronous motor in its working and its uses as a power factor correcting device
- To analyze the construction according to working, circuit, phasor diagrams of Synchronous machine
- To create the concepts about operation of alternator and its methods of voltage regulation

Course Outcomes (COs)

1. Understand the DC machine and its commutation technique, armature reaction problem and improvements
2. Apply the starting of DC motors, losses calculations with the help of tests performed on the motor
3. Analyze the synchronous machine on the basis of construction, winding arrangements, impact of armature reaction on the same
4. Analyze the concept of synchronization, load sharing of alternators and few methods to define the voltage regulation of alternators
5. Analyze the synchronous motor as a power factor correcting device on the basis of performance characteristics of V and inverted V curves and also the losses to improve the efficiency

Articulation Matrix

(Program Articulation Matrix is formed by the strength of correlation of COs with POs and PSOs. The strength of correlation is indicated as 3 for substantial (high), 2 for moderate (medium) correlation, and 1 for slight (low) correlation)

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	1	-	-	-	-	-	2	1	-
CO2	3	2	1	-	-	1	-	-	-	-	-	-	1	1	1
CO3	2	3	1	-	-	-	1	-	-	-	-	-	1	1	-
CO4	2	1	-	-	-	1	-	-	-	-	-	-	-	1	-
CO5	2	1	-	-	-	1	-	-	-	-	-	-	-	1	1

High-3 Medium-2 Low-1

UNIT I: D.C. Machine-I **9 Hours**

Working principle, construction of DC machines, types of DC machines and method of excitation, lap and wave windings, e.m.f. equations, armature reaction, effect of brush shift, compensating winding, commutation, causes of bad commutation, methods of improving commutation, basic performance of DC generators and their performance characteristics

UNIT II: D.C. Machine-II **9 Hours**

Basic operation of dc motors, torque equation; operating characteristics of dc motors, 2-point, 3-point and 4-point starters of DC motors, speed control methods: field and armature control, braking: plugging, dynamic and regenerative braking, testing: Hopkinson's test, estimation of losses and efficiency

UNIT III: Synchronous Machine-I **9 Hours**

Constructional features, excitation system including brushless excitation; polyphase distributive winding, synchronous generator- generated e.m.f., circuit model and phasor diagram, armature reaction

UNIT IV: Synchronous Machine-II **9 Hours**

Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics, parallel operation of alternators - synchronization and load division, Synchroscopes and phase sequence indicator.synchronous reactance and impedance, equivalent circuit of alternator, voltage regulation of alternators using synchronous impedance, mmf and zpf method

UNIT V: Synchronous Machine-III **9 Hours**

Synchronous motor - operating principle, circuit model, Operating characteristics of synchronous machines, V-curves and inverted V-curves, synchronous motors as power factor correcting device, super synchronous, hunting and damper winding efficiency and losses, starting methods of synchronous motors

Total: 45 Hours

PRACTICAL

1. Study Constructional features of DC Motor
2. Study the 2- Point and 3- Point of DC Motor
3. Study the 4- Point Starter of DC Motor
4. Perform armature control method of speed control of separately excited D. C. Motor
5. Perform field flux control method of speed control of shunt D. C. Motor
6. Study Commutation Process and Slip Ring of DC Machine
7. Perform Hopkinson Test on a DC Generator and Motor Set
8. Study Constructional Features of Synchronous Machine
9. Study the Synchroscopes of Synchronous Machine
10. Perform V Curve Method on Synchronous Motor

Total: 75 Hours

Reference(s)

1. M.G. Say, Performance & Design of AC Machines, CBS Publishers & Distributors, Delhi, 3rd Edition
2. A.E. Clayton & N.N. Nancock, the Performance & Design of DC Machines CBS Publications & Distributors, Delhi, 3rd Edition
3. P.S. Bhimbra, Electrical Machinery, Khanna Pub
4. P.S. Bhimbra, Generalized Theory of Electrical Machines, Khanna publishers, Delhi
5. Ashfaq Husain, Electric Machines, Dhanpat Rai, New Delhi
6. I.J. Nagrath& D.P. Kothari, Electric Machines, Tata McGraw Hill, New Delhi

List of e-Learning Resources:

3. https://onlinecourses.nptel.ac.in/noc23_ee55/preview
4. https://www.coursera.org/learn/motors-circuits-design

Subject Expert	**Academic Coordinator**	**HoD**	**Appointed Senior Faculty by DoAA**

MandsaurUniversity

B.Tech Electrical and Electronics Engineering (EVT)

Semester-IV

L-2, T-1, P-2, C-4

Power System-I (EEE280)

Course Objective

- To introduce the concepts and phenomenon of different source of power generation
- To give an idea about the fundamental concepts of electrical power distribution, both ac &dc
- To familiarize the students with the tariff methods for electrical energy consumption in the prospect of optimum utilization of electrical energy
- To impart the knowledge of different turbines used in the generating stations with the analytical methods
- To introduce the concepts and design power system components for a specified system and application

Course Outcomes(COs)

1. Understand the articulatepowersystemconceptsrequiredtoengineering problems
2. Apply and designpowersystemcomponentsfor aspecifiedsystemand application
3. Analyze anddiscussvariouspowersourcesforgenerationofpowermerit/demerits
4. Evaluate theA.CandD.Cdistributionnetworksfornecessaryvariable calculation
5. Evaluatetocalculateusageofelectricalpower distribution systemAc Phase

ArticulationMatrix

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	-	-	-	-	-	2	1	-	1
CO2	2	2	3	1	1	1	-	-	-	-	-	2	1	-	1
CO3	3	2	2	1	1	1	-	-	-	-	-	2	1	-	1
CO4	2	3	2	2	1	1	-	-	-	-	-	1	1	-	1
CO5	2	3	1	1	1	2	-	-	-	-	-	1	1	-	1

High-3Medium-2Low-1

Unit-I Generation System 9 Hours

An Overview of Electrical Energy Generation General Background, Structure and Components of PowerNetwork.PowerGeneration–Introductionto Conventional,Non-Conventional&Distributed Generation, Effect of Transmission Voltage on Power System Economy. Selection of Size of Feeder

PowerPlantEconomics

Load Curves, Base Load, Peak Load, Load Factor, Demand Factor, Diversity Factor, Capacity Factor, Utilization Factor, Cost of Electricity, Capital Cost, Fuel and Operation Cost

Unit-II Transmission Line Components & Under Ground Cabling
9Hours

InductanceResistanceandCapacitanceof TransmissionLine,Calculationof Inductancefor1-Φ and3-Φ,SingleCircuitLine,EffectofGroundorCapacitance,CapacitanceCalculationfor SymmetricalandAsymmetrical1-PhaseandThreePhase,SingleandDoubleCircuitLine, Charging Current, Transposition ofLine, Composite Conductor, Skin and Proximity Effect, Bundle Conductor.ComparisonofCablesandOverheadTransmissionlines,ClassificationofCables, Phenomena of Dielectric Losses and Sheath Loss in Cables, Thermal Resistance of Cables

Unit-IIITransmissionSystems 9Hours

Transmission Systems & Performance of Transmission Line Various Systems of Transmission, Effect of System Voltage. Short, Medium & Long Transmission Line and Their Representation, NominalT, NominalΠ, Equivalent T and Equivalent Π Network Models, MathematicalSolutionto Estimate Regulation & Efficiency of all Types of Lines. Surge Impedance Loading, Tuned Power Lines

Unit-IVMechanicalDesign
9 Hours

Insulator & Mechanical Design Mechanical Design Types of Conductors Used in Overhead Transmission Line, Types of Line Supports and Towers, Spacing between Conductors, Length of Span and Sag, Tension Calculation for Transmission Line, Wind & Ice Loading, Support ofLine at Two Different Levels, VibrationandVibrationDampers. InsulatorMaterialsUsed forTransmission Line Insulation, Types of Insulator for Overhead Transmission Line Failure of

Insulator, Voltage Distribution of Suspension Insulator, String Efficiency

Unit-VDistributionSystem9 Hours

Voltage Control & Distribution SystemAc Single Phase, 3 Phase, 3Wire & 4 Wire Distribution, Kelvin's Law for most Economical Size ofConductor Substation Layout Showing Substation Equipment, Bus Bar Single Bus Bar and Sensationalized Bus Bar, Main and Transfer for Bus Bar System, Sensationalized Double Bus Bar System, Ring Mains

Total: 45Hours

SuggestedList ofExperiment:-

1. Study&DrawDifferentTypesofElectrical&Electronics Symbols
2. Studythe HydroPowerStation
3. Studythe NuclearPowerStation
4. Studythe ThermalPowerStation
5. StudytheDrawDifferentTypesofInsulator
6. Study&Draw TowersUsedinTransmissionLine
7. Studythe DifferentTypesofPowerCable
8. Study&DesignElectricalPowerSystem
9. Study&DesignElectricalPowerTransmissionLine
10. DeterminationofTransmissionParametersofatransmissionLine

Total: 75 Hours

References:-

1. WilliamStevenson (2011),ElementsofPower SystemAnalysis,McGraw Hill
2. C.L.Wadhwa(2009),ElectricalPowerSystemAnalysis,NewAgeInternational
3. D.P.Kothari,I.J. Nagrath (2008), ModernPowerSystemAnalysisTMH
4. D.P.Kothari, I.J.Nagrath (2009), PowerSystemEngineeringTMHII
5. JohnGraingerandWilliamStevenson(2011),PowersystemAnalysis,McGrawHill
6. AshfaqHusain(2006),ElectricalPowerSystems,VikasPublishingHouse

Listofe-Learning Resources:

1. https://nptel.ac.in/courses/108/105/108105104/
2. https://www.coursera.org/learn/electric-power-systems

Subject Expert	Academic Coordinator	HoD	Appointed Senior Faculty by DoAA

Mandsaur University

B.Tech- Electrical and Electronics Engineering
Semester-IV

L-2 T-1 P-2 C-4

PEEEE0201A: Digital Electronics & Logic Design

Course Objectives:

- Understand various number systems and to simplify the mathematical expressions using Boolean functions – simple problems.
- Apply the fundamentals of digital circuits, combinational and sequential circuit.
- Apply design of combinational circuits
- Analyze of various synchronous and asynchronous circuits.
- Analyze registers and memories.

Course Outcomes (COs)

1. Understanding the fundamental concepts and techniques used in digital electronics.
2. Examine the structure of various number systems and its application in digital design.
3. Analyze and design various combinational and sequential circuits.
4. Analyze minimization techniques for the development of digital circuits.
5. Analyzed various types of digital circuits and studied knowledge in memory devices.

Articulation Matrix

(Program Articulation Matrix is formed by the strength of correlation of COs with POs and PSOs. The strength of correlation is indicated as 3 for substantial (high), 2 for moderate (medium) correlation, and 1 for slight (low) correlation)

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	1	2	-	-	-	-	-	1	2	2	1
CO2	3	3	3	2	3	1	-	-	2	-	1	3	3	1	3
CO3	3	2	2	2	2	2	-	-	2	-	1	1	2	2	1
CO4	2	3	2	2	2	1	-	-	2	-	2	1	3	2	2
CO5	3	3	3	3	3	3	-	-	3	-	2	2	3	2	2

High-3 Medium-2 Low-1

Unit-I Number Systems, Boolean Algebra and Simplification of Boolean Functions **12 Hours**

Digital Number Systems, Base Conversion, Binary, Decimal, Octal, Hexadecimal, Number System with Radix r, Gray Codes. ASCII code, EBCDIC Codes, Hollerith Code, Concept of Parity, Complement r's & (r-1)'s, Subtraction with Complements, Signed Binary Numbers, Digital Logic Gates. Basic Definition, Axiomatic Definition of Boolean Algebra, Basic Theorem and Properties of Boolean Algebra, Demorgon's Theorem. Negative Logic, Representation (Concept of Bubbled Gates) Canonical and Standard Forms (Minterms & Maxterms**),** Sum of Minterms & Product of Maxterms, Conversion Between Canonical Forms. Simplification of Boolean Functions: Different Types Map Method, Product of Sum Simplification, NAND or NOR Implementation, Don't Care Condition.

Unit-II Design of Combinational Circuits **9 Hours**

Design of Adder, Subtractor, Comparators, Code Converters, Encoders, Decoders, Multiplexers and Demultiplexers. Introduction, Code Conversion, Universal Gate. Introduction, Binary Parallel Adder, Decimal Adder, Magnitude Comparator.

Unit-III Sequential Logic Circuits **9 Hours**

Introduction of Sequential Circuits, Flip-Flops, Latches, S-R FF, J-K FF, D FF, T FF, Edge

Triggered Flip Flop, J-K Flip Flop, T Flip Flop, Master Slave Flip Flop Triggering of Flip-Flops, Analysis of Clocked Sequential Circuits, State Reduction and Assignment, Flip-Flop Excitation Tables, Design Procedure and applications of Flip flop.

Unit-IV Counters **8 Hours**

Asynchronous and Synchronous Counter, Counters with MOD Numbers, Down Counter, UP/DOWN Counter, Propagation Delay in Ripple Counter, Programmable Counter, Pre-settable Counter, BCD Counter, Cascading, Counter Applications, Decoding in Counter, Decoding Glitches, Ring Counter, Johnson Counter, Rotate Left & Rotate Right Counter. Counter

Unit V Registers and Memories **7 Hours**

Registers – Buffer, Shift Left, Shift Right, Shift Left/Right Registers, Parallel in Parallel Out, Serial in Serial Out, Parallel in Serial Out, Serial in Parallel Out Registers.
Memories: ROM, PROM, EPROM, PLA, PLD.

Total: 45 Hours

Practical List:

1. To study and verify the operation of all logic Gate
2. To study the NAND and NOR Gate as Universal Gate
3. To prove Demorgan's Theorem
4. To study Binary to Gray conversion and Gray to Binary conversion
5. To study Binary to Excess-3 conversion
6. To study Binary adder/ Subtractor
7. To study Encoder/Decoder
8. To study Multiplexer/ Demultiplexer
9. To study Flip-Flops
10. To study 4 bit Shift Register

Total: 75 Hours

Reference(s)

1. M. Mano; Digital design; Pearson Education Asia
2. Thomas Blakeslee; Digital Design with standard MSI and LSI; Wiley Interscience
3. Jain R P; Modern Digital Electronics; TMH
4. M. Mano; Digital Logic & Computer Design; PHI
5. Tocci ; Digital Systems Principle & Applications; Pearson Education Asia
6. Gothmann; Digital Electronics; PHI
7. R. H. Gour; Digital Electronics and Micro Computer
8. Malvino, Leech; Digital Principles and Applications
9. Floyad; Digital Fundamentals (UBS)
10. D.C. Green; Digital Electronics (Pearson Education Asia)
11. S. Salivahanan; Digital Circuits and Design.

List of e-Learning Resources:

1. https://nptel.ac.in/courses/117106086
2. https://www.coursera.org/learn/digital-systems

Subject Expert	**Academic Coordinator**	**HoD**	**Appointed Senior Faculty by DoAA**

B.Tech - Electrical& Electronics Engineering (EVT)

Semester-IV

L-2 T-1 P-2 C-4

PEEEE0301A: Electrical and Electronics Instrumentation

Course Objectives

- To learnprinciples and applications of measurement system in everyday life
- To understand the working of analog instruments used for electrical measurement
- To define and understand the basic of magnetic and energy measurement
- To develop the concepts about transducers and signal conditioners
- To learn about ac bridges and display devices.

Course Outcomes (COs)

1. Understand the concepts of measurement and instrument system
2. Identify thedifferent instruments used for electrical parameters measurement
3. Design and analyze the magnetic measurement and energy measurement instruments
4. Analyze the working of transducers and signal conditioners
5. Design and examine of ac bridges and display devices

Articulation Matrix

(Program Articulation Matrix is formed by the strength of correlation of COs with POs and PSOs. The strength of correlation is indicated as 3 for substantial (high), 2 for moderate (medium) correlation, and 1 for slight (low) correlation)

CO/PO/ PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO2	1	3	2	-	-	-	-	-	-	-	-	1	-	-	-
CO3	1	2	3	-	-	-	-	-	-	-	-	1	1	-	1
CO4	1	2	3	1	1	-	-	-	-	-	-	1	1	1	-
CO5	1	2	2	2	1	-	-	-	-	-	1	1	2	1	1

High-3 Medium-2 Low-1

Unit I: Philosophy of Measurement — 09 Hours

Methods of Measurement, Measurement System, Classification of instrument System, Characteristics of Instruments & Measurement System, Errors in Measurement & Its Analysis.

Unit II: Analog Measurement of Electrical Quantities — 09 Hours

Theory and Construction of Voltmeter, Ammeter, Ohmmeter, Wattmeter, Multimeter, Theory and Construction of Current and Potential Transformers, Characteristics of Current Transformers (CT) & Potential Transformers (PT) and Their Testing.

Unit III: Magnetic and Energy Measurement — 09 Hours

Flux Meter, B-H Curve, and Hysteresis loop, iron Loss Measurement by Wattmeter and Bridge Methods, Single Phase and Three Phase Energy Meter. Energy Meter – Construction & Operation, Power Factor Meter– Single Phase and Three Phase.

Unit IV: Transducers and Signal Conditioners — 09 Hours

Definition and Classification, Strain Gauges, Gauge factor, Thermistor, LVDT Thermocouples, Piezo-Electric transducers constructional details, characteristics and applications, Purpose of signal conditioning, Classification, Operational amplifiers, A/D and D/A converters.

Unit V : AC Bridges and Display Devices: — 09 Hours

Sources and detectors, use of bridges for measurement of inductance, Capacitance & Q factor. Maxwell's bridge, Maxwell's inductance capacitance bridge, Hays bridge, Wien's bridge, Introduction to CRO, Block diagram, Seven Segment LED, LED, and LCD.

Total: 45 Hours

PRACTICALS:-

1. Measurement of different electrical parameters through Multimeter
2. Study of Current Transformer
3. Study of Potential Transformer
4. Measurement of Electric load by of Energy Meter
5. Measurement of temperature by using LM35
6. Measurement of temperature by using Platinum RTD
7. Measurement of linear displacement by LVDT and draw its characteristics.
8. Implementing inverting &non inverting mode of Op-amp 741 IC
9. Measurement of Gauge Factor by Strain Gauge
10. Measurement of inductance of a coil using Maxwell's bridge

Total: 75 Hours

Reference(s)

1. A. K. Sawhney, A course in Elect. & Electronic Measurement and Instrumentation, Dhapat Rai
2. Golding &Widis, Electrical Measurement and Measurement instrument, Wheelar Books.
3. H.S. Kalsi, Electronic Instruments, Tata Mc-Graw hill.

List of e-Learning Resources:

1. https://nptel.ac.in/
2. https://www.coursera.org/

Subject Expert	**Academic Coordinator**	**HoD**	**Appointed Senior Faculty by DoAA**

B. Tech - Electrical & Electronics Engineering (EVT)

Semester-IV

PEEEE0303A Energy Storage System and Management System

L-2 T-1 P-2 C-4

Course Objectives

- To Learn about different types of energy storage system.
- To Understand the concepts of the battery characteristic & parameters.
- To Define and understand the different types of batteries.
- To Analysis of the battery management system and design the battery pack.
- To Examine the working of battery testing, disposal and recycling.

Course Outcomes (COs)

1. Understand the fundamental concepts of various energy storage system.
2. Understand the need of battery characteristic & parameters.
3. Analyze of various batteries.
4. Evaluate and analyze battery management system.
5. Analyze the various methods of battery testing, disposal and recycling.

Articulation Matrix

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CO/PO/PSO	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO12	PSO1	PSO2	PSO3
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CO2	2	3	1	-	-	-	-	-	-	-	-	-	1	-	-
CO3	1	2	3	1	-	-	-	-	-	-	-	1	-	-	-
CO4	1	2	2	3	-	-	-	-	-	-	-	-	-	1	-
CO5	1	1	2	1	1	-	-	-	-	-	-	-	-	-	-

High-3 Medium-2 Low-1

Unit-I — 09 Hours

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

Unit-II — 09 Hours

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

Unit-III — 09 Hours

BATTERY MODELLING:- 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 — 09 Hours

BATTERY PACK AND BATTERY MANAGEMENT SYSTEM:- Selection of battery for EVs & HEVs, Traction Battery Pack design, Requirement of Battery Monitoring, Battery State of Charge Estimation methods, Battery Cell equalization problem, thermal control, protection

interface, SOC Estimation, Energy & Power estimation, Battery thermal management system, Battery Management System: Definition, Parts: Power Module, Battery, DC/DC Converter, load, communication channel, Battery Pack Safety, Battery Standards & Tests.

Unit-V **09 Hours**

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

Total: 45 Hours

PRACTICALS:-

1. Measuring charging and discharging characteristics of Lead-acid batteries at different C-rates.
2. Measuring charging and discharging characteristics of Li batteries at different C-rates.
3. Measuring discharging characteristics of fuel cells at different C-rates.
4. Interfacing of batteries with power electronics converters and feeding R-L loads.
5. Analysis on induction motor drives fed by batteries.
6. To plot charging and discharging behavior curves of a capacitor.
7. Measuring charging characteristics of a Ni-Cd battery using solar photovoltaic panel.
8. Measuring effect of temperature on the performance of fuel cell
9. To plot the voltage - current characteristics of Fuel Cell
10. Performance estimation of a fuel cell.

Total: 75 Hours

Reference(s)

1. Ibrahim Dinçer, Halil S. Hamut and Nader Javani, “Thermal Management of Electric Vehicle Battery Systems”, John Wiley& Sons Ltd., 2016.
2. Chris Mi, Abul Masrur& David Wenzhong Gao, “Hybrid electric Vehicle- Principles & Applications with Practical Properties”, Wiley, 2011.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric Hybrid Electric and Fuel Cell Vehicles”, Taylor& Francis Group, 2010.

List of e-Learning Resources:

5. https://nptel.ac.in/
6. https://www.coursera.org/

Subject Expert	**Academic Coordinator**	**HoD**	**Appointed Senior Faculty by DoAA**