Dr. B. C. Roy Engineering College, Durgapur
An Autonomous Institute
(approved by AICTE & affiliated to MAKAUT)

Programme Code: 016
Programme : B.Tech in Electrical Engineering
Year (Semester) : 4th Year (7th Semester)

Sl. No.	Broad Category	Course Category	Course Type	Course Code	Course Name	Contact Hours/Week				Credits
						L	T	P	Total	
A. Theory										
1	ENGG	Major	PC	EE-701	Electric and Hybrid Vehicles	3	0	0	3	3
2	HUM	Ability Enhancement Courses	HM	EE-702	Principles of Management	2	0	0	2	2
3	ENGG	Major	PE	EE-703	High Voltage Engineering	3	0	0	3	3
				EE-704	Energy Management, Auditing & Safety					
				EE-705	Smart Grid Technology					
				EE-706	HVDC Transmission					
4	ENGG	Multidisciplinary	OE	EE-713	Optimization Techniques	2	0	0	2	2
				EE-714	Digital Image Processing					
				EE-715	Database Management Systems					
				EE-716	Big Data Analytics					
5	ENGG	Multidisciplinary	OE	EE-723	Internet of Things	2	0	0	2	2
				EE-724	Block Chain Technology					
				EE-725	Cloud Computing					
				EE-726	Digital Twin Technology					
TOTAL Theory						12	0	0	12	**12**
B. Practical/Sessional										
1	PROJ	Internship*	PC	EE-781	Seminar on Vocational Training/Internship - I	0	0	0	0	1
2	PROJ	Project	PC	EE-782	Major Project - I	0	0	4	4	2
3	ENGG	Major	PC	EE-791	Electric and Hybrid Vehicles Laboratory	0	0	2	2	1
4	ENGG	Skill Enhancement Courses	PC	EE-792	Android App Development Laboratory	0	0	2	2	1
TOTAL Practical/Sessional						0	0	8	8	**5**
TOTAL of Semester						12	0	8	20	**17**

* Students have to complete Internship/Vocational Training to earn Credit point subjected to appearance in the Seminar and submission of Certificate(s).

Dr. Shibendu Mahata
Chairman, BOS(EE)

ELECTRIC AND HYBRID VEHICLES

Course Code: EE-701

1. **Course Pre-requisites:**
   1. Power System -I
   2. Power Electronics
   3. Engineering Mechanics

2. **Course Learning Objectives:**
   To deliver and discuss the about architecture, power electronics-based drive control systems, battery management systems and grid integration issues of Electric and Hybrid vehicles.

3. **Course Name: Electric and Hybrid Vehicles**
   Course Code: EE-701
   Hours per Week: 3
   Credits: 3

   Course Contents:

Module	Topics	38L
1.	**History of Electrical Vehicle:** Introduction History Electrical Vehicle, Economical and Environmental Impact of Electric Hybrid Vehicle.	03
2.	**Architecture of Electric and Hybrid Electric vehicle:** Motion and dynamic equations for vehicles, Vehicle Power Plant and Transmission Characteristics, Basic Architecture and Power Flow Analysis of Electric and Hybrid Electric Drive-trains. Torque Coupling and Analysis of Parallel Drive-train.	07
3.	**DC-DC & DC-AC Converters:** DC-DC Converters for EV and HEV Applications, Boost and Buck-Boost Converters, Multi-Quadrant DC-DC Converters, DC-AC Inverter for EV and HEV Applications, Speed Control of vehicle Using PWM Inverters.	09
4.	**Electrical Machines for Hybrid and Electric Vehicles:** Induction motor drives, their control and applications in EV/HEVs, Permanent magnet motor drive, configurations, control, optimization, and applications in EV/HEVs, BLDC motor drive and Switch reluctance motor drive.	09
5.	**Energy Storage and controlling method of vehicles:** Introduction to battery management system (BMS). Mathematical Modeling for Lead acid battery, Alternative and Novel Energy Sources like Fuel Cell. Different types of Hybrid ECU with their application, The Fuzzy Logic Based Control System, Fundamentals of Regenerative Braking, Design of a Battery Electric Vehicle (BEV) and Hybrid Electric Vehicle (HEV),	10

4. **Text Books:**

T1: Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley.

T2: Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi CRC Press, 2004.

T3: C.C. Chanand, K.T. Chau, Modern Electric Vehicle Technology, Oxford Science Publication,

T4: Husain, Electric and Hybrid Electric Vehicles, CRC Press, 2003.

5. **References:**

R1: Modeling for Hybrid and Electric Vehicles Using Simscape, Shuvra Das, Morgan and Claypool publishers

R2: Electric and Hybrid Vehicles, Iqbal Husain, CRC Press

R3: Electric And Hybrid Electric Vehicles, James D. Halderman & Curt Ward, Pearson

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Depending on available resources, select an appropriate driving system for creating an electric hybrid car.	Analyze, Identify	Understand, Remember
CO2	Create and develop fundamental electric car and Hybrid vehicle schemes.	Identify, Select	Understand, Apply, Analyze
CO3	Select the appropriate energy storage devices for use in automobiles.	Identify, Select	Understand, Apply
CO4	Various energy-management techniques into practice for hybrid cars.	Analyze	Understand, Apply, Analyze
CO5	Development and design of Network Configuration	Identify	Analyze

7. **Mapping of course out comes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	2	3	-	-	-
3	2	-	3	-	-
4	3	-	3	3	-
5	3	-	-	-	3

8. Mapping of CO to PO:

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

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	2	1	2
CO3	3	2	1	2
CO4	3	2	2	1
CO5	3	2	1	2

PRINCIPLES OF MANAGEMENT
Course Code: EE-702

1. **Course Prerequisite: NIL**

2. **Course Learning Objectives:**

   To understand basic concept and approaches to management, to understand planning and decision-making processes, to understand organizational design and structure and to understand various aspects of leadership.

3. **Course Name: PRINCIPLES OF MANAGEMENT**
   Course Code: EE-702
   Hours per Week: 2
   Credits: 2

Course Content:

Module	Topics	28L
1.	**Concept & approaches to management:** Meaning & Definition of the term Management, Management as a Science or an Art, Management as a Profession, Management as a Process, Difference between Management & Administration; Levels of Management, Roles of a Manager, Quality of a good Manager, Significance of Management, Limitations of Management, Business Environment and its interaction with Management. Approaches to Management – Classical, Neo-classical and Modern Contributors to Management Thought – Taylor and Scientific Theory, Fayol's and Administrative Theory, Peter Drucker and Management Thought. Various Approaches to Management (i.e., Schools of Management Thought) Indian Management thought	06
2.	**Planning & decision making: Planning**: Meaning, Definition, Process, Types, Principles, Significance & Limitations of Planning; Strategic Planning – Meaning & Process, MBO – Meaning, Process and Requirements for Implementation, Planning Premises – Meaning & Types, Forecasting – Meaning & Techniques. Decision Making – Meaning, Types, Process, Significance & Limitations	06
3.	**Organization design & Structure**: Organization – Meaning, Process, Principles, Organization Structure – Determinants and Forms: Line, Functional, Line & Staff, Project, Matrix and Committees; Formal and Informal Organization; Departmentation – Meaning and Bases; Span of Control – Meaning and Factors Influencing; Authority, Responsibility and Accountability; Delegation – Meaning, Process; Principles; Centralization and Decentralization – Meaning; Degree of Decentralization; Difference between Delegation and Decentralization.	07

4.	**Directing:** Motivation – Meaning, Definition, Significance & Limitations; Financial and non-financial incentives of Motivation Leadership - Meaning, Definition, Significance of Leadership, Leadership styles Type, Process and Barriers of Communication, Strategies to overcome the Barriers.	04
5.	**Customer Management:** Market Planning & Research, Marketing Mix, Advertising & Brand Management. Operations & Technology Management – Production & Operations Management, Logistics & Supply Chain Management, TQM, Kaizen & Six Sigma, MIS.	05

4. Text Books:

T1: Koontz and H. Weihrich, Essentials of Management. Tata McGraw Hill 7th Edition
T2: El Premvir Kapoor, Principles of Management Khanna Publishing House, 2019
T3: Dipak Kumar Bhattacharyya, Principles of Management- Text and Cases Pearson Education India, 2011

5. References:

R1. V.S.P Rao & Hari V. Krishna Management-Text & Cases Krishna, Excel Books, 2005
R2. T. Ramaswami Principles of Management Himalaya Publishing House, 2014
R3. Ray Gehani Management of Technology and Operations Wiley, 1998

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the concepts and approaches of management	Analyze, Identify	Understand, Remember
CO2	Demonstrate the roles, skills and functions of management	Identify, Select	Understand, Apply, Analyze
CO3	Diagnose and solve organizational problems	Identify, Select	Understand, Apply
CO4	Identify the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities	Analyze	Understand, Apply, Analyze
CO5	Apply different methods of Customer, Operation and Technology management	Identify	Analyze
CO6	Acquire skills of good leader in an organization.	Implement	Evaluate

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	1	2	-	-	-	-
2	-	-	3	3	-	-
3	-	2	3	3	-	-
4	-	-	-	2	-	2
5	-	-	-	2	2	2

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	2	-	-	-	-	-	-	-	-
CO2	-	-	-	2	-	2	1	-	-	-	-
CO3	-	-	-	2	-	2	-	-	2	-	2
CO4	-	-	-	-	-	-	2	2	2	2	-
CO5	-	-	-	2	2	2	-	-	2	-	-
CO6	-	-	-	-	-	-	-	2	2	2	2

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-
CO2	-	-	2	2
CO3	3	-	2	2
CO4	3	-	3	2
CO5	-	-	3	2
CO6	-	-	3	2

HIGH VOLTAGE ENGINEERING

Course Code: EE-703

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1. **Course Prerequisite:**
   1. Electromagnetic Field Theory
   2. Power System-I
   3. Electrical and Electronics Measurements
   4. Power System-II

2. **Course Learning Objectives:**
   This course is designed to review the fundamentals and practices of insulating materials and their applications in electrical and electronics engineering, breakdown phenomenon in insulating material (solid, liquid, and gases), generation and measurement of high D.C., A.C. and impulse voltages and currents, overvoltage phenomenon in electrical power system and insulation coordination, high voltage testing techniques.

3. **Course Name: HIGH VOLTAGE ENGINEERING**
   Course Code: EE-703
   Hours per Week: 3
   Credits: 3

Course content:

Module	Topics	36L
1.	**Overview of High Voltage Engineering**: Air as an Insulation, Concept of Dielectric Strength, Electric field and electrode configuration, Parameters for dependence of Dielectric strength, Introduction to Breakdown of Insulation.	05
2.	**Breakdown of Gases, Solids and Liquids:** Gases: Ionization and decay processes, Townsend's criterion, Paschen's law, streamer theory, and breakdown in electronegative gases. Liquids: Electronic breakdown, breakdown in pure and commercial liquids. Solids: Intrinsic, electromechanical, and thermal breakdown in solid dielectrics, as well as breakdown in composite materials.	08
3.	**Generation of AC high voltages and DC High Voltages:** Generation using transformers in cascade, series resonant circuits, and testing transformers for AC voltage. Generation using rectifier circuits (half and full wave), and electrostatic generators for DC voltage.	05
4.	**Generation of impulse voltages and currents:** Analysis of different circuits, Marx multi-stage impulse generator.	05
5.	**Methods of measuring high voltage and high currents of power frequency and D.C and Impulse:** Methods for measuring AC, DC, and impulse voltages and currents using electrostatic voltmeters, sphere gaps, potential dividers, and other specialized instruments.	05

6.	**Introduction to Lightning phenomenon, Insulation Co-ordination.** Brief reviews of high voltage testing-Methods for different power system equipment.	08

4. Text Books:

T1: M S Naidu & Kamraju, High Voltage Engineering, Tata McGraw-Hill Publishing Company Ltd.
T2: C.L.Wadhwa, High Voltage Engineering, New Age International Publisher

5. References:

1. Kueffel & Zangel, High Voltage Engineering Fundamentals, Newnes An imprint of Butterworth- Heinemann Linacre House, A division of Reed Educational and Professional Publishing Ltd.
2. J Lucas, High Voltage Engineering, Katson book.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Recall importance of high voltage technology.	Analyze, Identify	Understand, Remember
CO2	To study the breakdown phenomena in different dielectrics.	Identify , Select	Understand, Apply, Analyze
CO3	Demonstrate generation of high voltages and Currents.	Identify , Select	Understand, Apply
CO4	Describe and analyze various measurement techniques for high Voltages and Currents.	Analyze	Understand, Apply, Analyze
CO5	Examine testing methods used for different HV apparatus.	Identify	Analyze
CO6	Evaluate insulation coordination among different HV apparatus.	Implement	Evaluate

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	2	3	-	-	-	-
3	2	-	3	-	-	-
4	3	-	3	-	-	-
5	3	-	-	3	-	-
6	3	-	-	-	-	3

8. **Mapping of the Course outcomes to Program Outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	1	-	-	-	-	1
CO2	3	3	3	2	2	1	-	-	-	-	1
CO3	3	3	3	3	2	2	-	-	-	-	1
CO4	3	3	3	3	2	1	-	-	-	-	1
CO5	3	3	3	3	2	1	-	-	-	-	1
CO6	3	3	3	2	2	2	1	-	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO 2	PSO 3	PSO 4
CO1	3	2	1	1
CO2	3	3	1	2
CO3	3	2	1	2
CO4	3	2	1	1
CO5	3	2	1	2
CO6	3	3	1	2

ENERGY MANAGEMENT, AUDITING & SAFETY
Course Code: EE-704

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1. Course Prerequisites:

1. Power System
2. Power Quality and FACTS

2. Course Learning Objectives:

The course "Energy Management, Auditing & Safety" is designed to equip students with the knowledge and skills necessary to effectively manage energy resources, conduct energy audits, and implement safety measures in various industrial and commercial settings. The primary learning objectives of this course include: Understanding Energy Management Principles, Conducting Energy Audits, Implementing Energy Conservation Measures, Financial and Economic Analysis and nursing Safety in Energy Management.

3. Course Name: ENERGY MANAGEMENT, AUDITING & SAFETY
Course Code: EE-704
Hours per Week: 3
Credits: 3

Course Content:

Module	Topics	36L
1.	**Energy Management Fundamentals:** Overview of global and Indian energy landscapes, including conventional and non-conventional energy sources, Energy Conservation Act 2001 (Understanding its significance and amendments), National and state-level policies promoting energy efficiency, Energy Management Principles (strategies for optimizing energy use in various sectors).	07
2.	**Energy Auditing Techniques:** Types of Energy Audits - Preliminary and detailed audits, Audit Methodology - Steps involved in conducting energy audits, including data collection and analysis, Energy Audit Instruments - Tools used for measuring and analysing energy consumption, Energy accounting and benchmarking, Monitoring tools like CUSUM analysis.	07
3.	**Project & Financial Management:** Project lifecycle and management tools (e.g., Gantt charts, CPM, PERT), Financial appraisal techniques: NPV, IRR, ROI and Risk and sensitivity analysis.	05
4.	**Energy Efficiency in Systems:** Efficiency in thermal and electrical utilities, Energy-efficient technologies and practices, Demand-side management strategies, IGBC guidelines for green buildings.	05
5.	**Renewable Energy & Sustainability:** Integration of renewable energy sources, Sustainable development principles, Environmental impact assessments. United nations sustainable development goals (SDG-1-17)	06

6.	**Safety in Energy Systems:** Ensuring safety in energy management practices, Recognizing potential risks in energy systems, Compliance with safety standards and protocols, Planning and response strategies for energy-related emergencies.	06

4. Text Books:

T1: Energy Audit and Management: Concept, Methodologies, Procedures, and Case Studies edited - L. Ashok Kumar & Gokul Ganesan, CRC Press.
T2: Guide to Energy Management - Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, The Fairmont Press, Inc.
T3: Industrial Energy Management and Utilization - Larry C. Witte, Philip S. Schmidt, and David R. Brown, Washington, Hemisphere Pub. Corp.

5. References:

R1: Energy Management and Efficiency for the Process Industries - Alan P. Rossiter and Beth P. Jones, Wiley online library.
R2: Fundamentals of Energy Management - Albert Thumann, Atlanta, Ga. : Fairmont Press, Englewood Cliffs, N.J. Prentice-Hall.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Grasp the fundamentals of energy management, including the significance of energy audits, various auditing techniques, and the use of energy audit instruments.	Analyse, Identify	Understand, Remember
CO2	Identify potential areas for energy savings in thermal and electrical systems, aiming to maximize and optimize system efficiency.	Identify, Select	Understand, Apply, Analyse
CO3	Develop and implement energy management plans considering cost-benefit analysis, environmental impact, and sustainability.	Identify, Select	Understand, Apply
CO4	Analyse energy management systems and prepare comprehensive energy audit reports, demonstrating the ability to evaluate and present findings effectively.	Analyse	Understand, Apply, Analyse
CO5	Understand and implement safety measures related to energy systems, ensuring compliance with relevant standards and regulations.	Understand	Analyse

CO6	Familiarize with energy legislation, codes and regulations, and comprehend their impact on energy management practices.	Analyse	Understand, Apply

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	3	-	
2	-	3	2	3	-	
3	-	-	2	2	2	
4	-	-	-	2	2	3
5	-	-	-	3	3	
6	-	-	-	3	3	3

8. Mapping of the Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	-	-	-	-	-	-	-	-	
CO2	3	3	3	2	2	1	-	-	-	-	-
CO3	-	-	3	3	2	2	-	-	-	-	-
CO4	3	3	3	3	2	-	-	-	-	-	2
CO5	-	-	-	-	2	2	2	1	2	-	-
CO6	-	-	-	-	-		-	3	2	2	2

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	-	2	-
CO2	3	3	3	-
CO3	3	-	3	-
CO4	3	2	2	2
CO5	3	-	2	2
CO6	3	-	2	2

SMART GRID TECHNOLOGY

Course Code: EE-705

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1. **Course Pre-requisites:**
   1. Power Systems
   2. Power Electronics

2. **Course Learning Objectives:**
   The learning objectives of smart grid technology focus on understanding its core concepts, components, and benefits, as well as its role in modernizing energy infrastructure and promoting sustainability.

3. **Course Name: SMART GRID TECHNOLOGY**
   Course Code: EE-705
   Hours per Week: 3
   Credits: 3

   Course Contents:

Module	Topics	36L
1.	**Introduction to Smart Grid:** Introduction, Definition of Smart Grid, Concept of Smart Grid Structure, Conventional Grid Vs Smart Grid, Smart Grid Domain, Opportunities and Barriers of Smart Grid, Smart Grid activities in India, Key Challenges for Smart Grid.	06
2.	**Smart Grid Architecture:** Components and Architecture of Smart Grid Design, Review of the proposed architectures for Smart Grid, Advanced metering infrastructure, The fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration.	06
3.	**Distributed Generation Technologies**: Introduction, Introduction to Renewable Energy Technologies, Micro Grids, Storage Technologies-Electric Vehicles and PHEVs, Environmental impact and Climate Change, Economic Issues.	08
4.	**Communication Technologies and Smart Grid:** Introduction, Two way digital communications paradigm, Synchro-Phasor Measurement Units (PMUs), Wide Area Measurement Systems (WAMS), Introduction to Internet of Things (IOT), Applications of IOT in Smart Grid, Cyber Security for Smart Grid.	08
5.	**Smart Grid Planning:** Planning aspects of Smart Grid, Operation and control of AC, DC and hybrid Smart Grid, Demand side management, Demand Response, Energy Management, Planning of Smart Grid Systems.	08

4. Text Books:

T1: A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2nd Edition, 2017.

T2: Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2012.

5. References:

R1: J. A. Momoh, "Smart Grid: Fundamentals of Design and Analysis," Wiley-IEEE Press, 1 st Edition, March 2012.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Able to understand the features and architecture of Smart Grid.	Analyze, Identify	Understand, Remember
CO2	Able to assess the role of automation in transmission and distribution.	Identify, Select	Understand, Apply, Analyze
CO3	Able to understand and analyze the operation of DG and storage technologies.	Identify, Select	Understand, Apply
CO4	Able to understand the communication technologies and cyber-security in Smart Grid.	Analyze	Understand, Apply, Analyze
CO5	Able to understand the planning, operation, control and analysis of Smart Electric Grid.	Identify	Analyze

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5
1	3	1	1	2	1
2	3	3	1	2	2
3	2	2	3	2	2
4	3	2	2	3	2
5	3	2	2	2	3

8. Mapping of CO to PO:

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

9. Mapping of CO to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	3	1	2
CO3	3	2	1	2
CO4	3	2	1	1
CO5	3	2	1	2

HVDC TRANSMISSION

Course Code: EE-706

1. **Course Pre-requisites:**
   1. Power Electronics
   2. Power System-I
   3. Control System

2. **Course Learning Objectives:**
   Understand the fundamentals of HVDC transmission, explore modern trends and applications of HVDC technology, analyse HVDC converter circuits, examine HVDC system components and operation, evaluate control and protection strategies, analyse power flow and stability in HVDC systems.

3. **Course Name: HVDC TRANSMISSION**
   Course Code: EE-706
   Hours per Week: 3
   Credits: 3

   Course Contents:

Module	Topics	38L
1.	**DC power transmission technology:** Introduction, comparison of AC and DC transmission, limitation of HVDC transmission, reliability of HVDC systems, application of DC transmission, description of DC transmission system, planning for HVDC transmission, modern trends in DC transmission.	04
2.	**Analysis of HVDC converters:** Pulse number, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics, Characteristics of a twelve-pulse converter, Detailed analysis of converters with and without overlap.	12
3.	**Converter and HVDC system control:** General, Principles of DC link control, Converter control characteristics, Firing angle control, Current and extinction angle control, Starting and stopping of DC link, Power control, control scheme of HVDC converters.	06
4.	**Harmonics and filters:** Generation of harmonics by converters, characteristics of harmonics on DC side, characteristics of current harmonics, characteristic variation of harmonic currents with variation of firing angle and overlap angle, effect of control mode on harmonics, non-characteristic harmonic. Filter configuration, design of band- pass and high pass filter, protection of filters, DC filters, power line communication and RF noise, filters with voltage source converter HDVC schemes.	06
5.	**Fault and protection schemes in HVDC systems:** Nature and types of faults, faults on AC side of the converter stations, converter faults, fault on DC side of the systems, protection against over currents and over voltages, protection of filter units.	04
6.	**Multiterminal HVDC systems:** Types of multiterminal (MTDC) systems, parallel operation aspect of MTDC. Control of power in MTDC. Multilevel DC systems.	06

4. **Text Books:**
   T1: HVDC Transmission, S. Kamakshaiah & V. Kamaraju, Tata McGraw hill education.
   T2: HVDC Power transmission system, K.R.Padiyar, Wiley Eastern Limited.

5. **References:**

R1: Power system stability and control, Prava Kundur, MGH.
R2: High Voltage Direct Current Transmission, J. Arrillaga, Peter Pregrinu.
R3: Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, New Age International (P) Ltd.
R4: High Voltage Direct Current Power Transmission, Colin Adamson and N. G. Hingorani, Garraway Limited, London.
R5: The Performance, Operation and Control of EHV Power Transmission Systems, A. Chakraborty, D.P. Kothary, A.K. Mukhopadhyay, Wheeler Pub.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand the advantages of dc transmission over ac transmission.	Analyze, Identify	Understand, Remember
CO2	Analysis of line commutated converters and voltage source converters in HVDC transmission system.	Identify, Select	Understand, Apply, Analyze, Evaluate
CO3	Application of suitable control strategies used for HVDC transmission system.	Identify, Select	Understand, Apply, Evaluate
CO4	Able to calculate voltage and current harmonics, and design of filters and understand the reactive power necessity of conventional control.	Analyze	Understand, Apply, Analyze
CO5	Protection requirements for HVDC transmission system faults.	Identify	Analyze
CO6	Analysis of multiterminal HVDC systems.	Implement	Understand, Apply, Analyze

7. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	-	-	-	3	-
6	-	1	1	-	-	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1	-	-	-	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-	-	-	-	1
CO3	3	2	2	2	2	1	-	-	-	1	1
CO4	3	2	2	1	2	1	-	-	-	-	-
CO5	3	2	1	2	2	1	-	-	-	1	1
CO6	3	2	2	2	2	1	-	-	-	1	1

9. Mapping to PSO:

	PSO1	**PSO2**	**PSO3**	**PSO4**
CO1	1	-	1	-
CO2	3	1	2	1
CO3	3	1	3	1
CO4	3	-	3	1
CO5	3	-	3	1
CO6	3	-	3	1

OPTIMIZATION TECHNIQUES

Course Code: EE-713

1. **Course Pre-requisites:**
   1. Power System-I
   2. Power System-II
   3. Power Generation Economics

2. **Course Learning Objectives:**
   The course equips students with the ability to understand and apply iterative methods and evolutionary algorithms, analyze their performance and design hybrid intelligent systems capable of solving complex real-world problems with adaptability, efficiency and tolerance to uncertainty.

3. **Course Name: Optimization techniques**
   Course Code: EE-713
   Hours per Week: 2
   Credits: 2

   Course Contents:

Module	Topics	28L
1.	Fundamentals of Soft Computing techniques, Definition-Classification of optimization problems-Unconstrained and Constrained Optimization-Optimality Conditions-Classical techniques (Interval halving method, Gradient-based methods).	06
2.	Lamda iteration method: Brief introduction to lamda iteration method, formulate the Lagrange function, Lamda iteration method to solve optimal dispatch problem.	05
3.	Differential Evolution: Fundamental principle, developing DE based solution techniques for OPF problems with single and multiple objectives and comparing the performance and computational effectiveness of DE with other evolutionary and conventional techniques.	05
4.	Particle Swarm Optimization: Fundamental principle, Velocity updating, Advanced operators, Parameter selection, Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO).	04
5.	Genetic Algorithm: Introduction to genetic Algorithm, working principle, Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators- Selection, Crossover and Mutation fitness function.	04
6.	Application of optimization techniques	04

4. Text Books:

T1: Optimization for Engineering Design, Kalyanmoy Deb, PHI Learning Pvt. Ltd.
T2: Power System Optimization, D.P. Kothari and J. S. Dhillon, PHI Learning Pvt. Ltd.

5. References:

R1: Principles of Soft Computing, S. N. Sivanandam, S. N. Deepa, Wiley India, 2nd Edition, 2011.
R2: Practical Genetic Algorithms, Haupt, R. L., Haupt, S. E. Wiley, 2004.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the fundamentals and classifications of optimization problems, including unconstrained and constrained methods, and their optimality conditions.	Analyze, Calculate,	Remember, Understand
CO2	Apply classical optimization techniques and the Lambda iteration method to solve optimal power dispatch problems.	Identify, Evaluate	Analyze, Create
CO3	Develop and implement Differential Evolution algorithms for optimal power flow (single and multi-objective) and compare their performance with other methods.	Measure, Assess	Evaluate, Create
CO4	Design and optimize Particle Swarm Optimization models, including advanced operators, parameter tuning, and hybrid PSO approaches.	Determine, Calculate	Create, Apply
CO5	Apply Genetic Algorithm principles, operators, and evolutionary strategies to solve engineering optimization problems.	Simulate, Analyze	Analyze, Apply
CO6	Formulate and implement soft computing–based solutions for economic load dispatch and hydro-thermal scheduling, using algorithm design and flowcharts.	Determine, Calculate	Create, Apply

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	1	-	-
2	1	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	3	-	-	3	-
6	-	-	-	-	-	3

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	2	-	-	-	-	-	1
CO2	3	3	1	1	2	-	-	-	-	-	1
CO3	3	3	1	1	2	-	-	-	-	-	1
CO4	3	3	1	1	2	-	-	-	-	-	1
CO5	3	3	1	1	2	-	-	-	-	-	1
CO6	3	3	1	1	2	-	-	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	2
CO2	3	3	1	1
CO3	3	-	1	1
CO4	3	-	2	1
CO5	3	2	-	2

DIGITAL IMAGE PROCESSING

Course Code: EE-714

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1. Course Pre-requisite:

1. Digital Signal Processing
2. Advanced Engineering Mathematics

2. Course Learning Objectives:

This course aims to provide the fundamental concepts and techniques of digital image processing, enabling students to understand, analyze, and apply image enhancement, restoration, compression, and segmentation methods.

3. Course Name: DIGITAL IMAGE PROCESSING

Course Code: EE-714
Hours per Week: 2
Credits: 2
Course Content:

Module	Topics	28L
1.	**Introduction to Digital Image Processing** – Origin and Applications of DIP, Image sensing and acquisition, Basic concepts of pixels, Sampling & Quantization, Image file formats	03
2.	**Digital Image Fundamentals** – Human visual system, Image resolution, Basic operations on images (Arithmetic, Logical, Geometric), Neighborhoods, Connectivity, Distance measures	03
3.	**Image Enhancement in Spatial Domain** – Intensity transformations, Histogram processing, Spatial filtering (Smoothing and Sharpening), Unsharp masking	05
4.	**Image Enhancement in Frequency Domain** – Fourier transform, Filtering in frequency domain, High-pass and Low-pass filters, Homomorphic filtering	05
5.	**Image Restoration** – Noise models, Noise reduction using spatial and frequency filters, Inverse filtering, Wiener filtering	03
6.	**Color Image Processing** – Color models (RGB, HSV, CMY), Pseudo-color and True-color processing, Color transformations	03
7.	**Image Compression** – Fundamentals of compression, Lossless (Huffman, Run-length) and Lossy (JPEG) techniques	03
8.	**Image Segmentation & Morphological Processing** – Edge detection (Sobel, Canny), Thresholding, Region-based segmentation, Morphological operations (Erosion, Dilation, Opening, Closing)	03

4. Text Books:

T1: Gonzalez, R. C., & Woods, R. E., *Digital Image Processing*, Pearson Education.

T2: Jain, A. K., *Fundamentals of Digital Image Processing*, Prentice Hall.

5. Reference Books:

R1: Pratt, W. K., *Digital Image Processing*, Wiley.
R2: Umbaugh, S. E., *Digital Image Processing and Analysis*, CRC Press.

6. Course Outcomes:

Course Outcome	Statement	Action Verb	Knowledge Level
CO1	Explain the fundamentals of image formation, sampling, and quantization	Explain	Understand
CO2	Apply spatial and frequency domain techniques for image enhancement	Apply	Apply
CO3	Implement basic noise models and image restoration techniques	Implement	Apply
CO4	Analyze color image models and transformations	Analyze	Analyze
CO5	Compare different image compression methods	Compare	Analyze
CO6	Apply segmentation and morphological techniques for feature extraction	Apply	Apply

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	1	-	-
2	2	3	-	-	-	-
3	2	-	3	-	-	-
4	-	-	3	3	-	1
5	-	-	-	3	3	-
6	1	-	-	-	-	3
7	-	-	1	1	2	3
8	1	-	-	1	3	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	2	-	1	-	-	-	2
CO2	3	2	2	3	2	1	-	-	-	-	-
CO3	3	3	3	2	2	-	1	-	-	-	-
CO4	3	3	3	3	2	1	1	-	-	-	1
CO5	3	3	3	3	2	1	2	-	-	-	-
CO6	3	2	3	2	1	-	2	1	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2
CO2	3	-	1	1
CO3	3	2	2	1
CO4	3	-	2	1
CO5	3	-	1	2
CO6	3	2	3	2

DATABASE MANAGEMENT SYSTEM
Course Code: EE-715

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1. **Course Pre-requisites:**
   1. Programing with C
   2. Data Structures & Algorithm

2. **Course Learning Objectives:**
   This course introduces the core principles and techniques required in the design and implementation of database systems. This course focus on relational database management systems, including database design theory: E-R modeling, data definition and manipulation languages, database security and administration. It also covers essential DBMS concepts such as: Transaction Processing, Concurrency Control and Recovery and various types of databases like distributed database, and intelligent database, Client/Server. Students undertake a semester project to design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementing a DBMS. It also provides students with theoretical knowledge and practical skills in the use of databases and database management systems in information technology applications.

3. **Course Name: DATABASE MANAGEMENT SYSTEM**
   Course Code: EE-715
   Hours per Week: 2
   Credits: 2

   Course Contents:

Module	Topics	27L
1.	**Introduction to DBMS:** Concept & Overview of DBMS, Applications, Data Models, Database Languages, Database Administrator, Database Users, Three Schema architecture of DBMS.	03
2.	**Entity-Relationship Model:** Basic concepts, Design Issues, Mapping Constraints, Keys, Entity-Relationship Diagram, Weak Entity Sets, Extended E-R features	04
3.	**Relational Model:** Structure of relational Databases, Relational Algebra, Relational Calculus, Extended Relational Algebra Operations, Views, Modifications of the Database.	04
4.	**SQL and Integrity Constraints:** Concept of DDL, DML, DCL. Basic Structure, Set operations, Aggregate Functions, Null Values, Domain Constraints, Referential Integrity Constraints, assertions, views, Nested Subqueries.	04
5.	**Index Structures:** Necessity of index structures, Types of Single-Level Index (primary, secondary, clustering), Multilevel Indexes, Dynamic Multilevel Indexes using B tree and B+ tree.	04

6.	**Normalization:** Functional Dependency, Anomalies in a Database, The normalization process: Conversion to first normal form, Conversion to second normal form, Conversion to third normal form and BCNF, Normalization and database design, Denormalization, Loss-less join decomposition.	04
7.	**Transaction processing:** Introduction of transaction processing, advantages and disadvantages of transaction processing system, online transaction processing system, serializability and recoverability, view serializability.	04

4. Text Books:

T1: R. Elmasri & S. B. Navathe, "Fundamentals of Database Systems", Pearson Education 7th Edition, 2017.

T2: "Database System Concepts", 6th Edition by Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill.

T3: "Distributed Databases Principles & Systems", Stefano Ceri and Giuseppe Pelagatti, McGraw-Hill International Editions.

5. References:

R1: An Introduction to Database systems, C.J. Date, A. Kannan, S. Swami Nadhan, Pearson, Eighth Edition for UNIT III.

R2: D Raghu Ramakrishnan and Johannes Gehrke, "Database Management Systems", Mc Graw Hill, 2014

R3: "Fundamentals of Database Systems", Ramez Elmasri and Shamkant B. Navathe, Addison-Wesley

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	To introduce students to the fundamentals of Database Systems.	Recognize	Understand, Remember
CO2	To train students to apply logical database design principles, including E-R diagrams and database normalization.	Explain	Understand, Apply, Evaluating
CO3	To focus on Relational data model concepts.	Illustrate	Understand, Apply
CO4	To enable students to construct simple and moderately advanced database queries using structured Query Language (SQL).	Organize	Understand, Apply, Analyze
CO5	To become familiar with the basic issues of transaction processing and concurrency control.	Determine	Evaluate
CO6	To encourage students to design and implement a small database project.	Construct	Create

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	1
2	-	3	2	1	-	1
3	-	3	-	-	1	1
4	-	3	2	-	-	1
5	-	-	-	2	-	1
6	-	-	-	1		1
7	-	-	-	-	3	1

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1	2	2	2	1	-	-	-	-	-	1
CO2	2	1	2	2	1	-	-	-	1	-	1
CO3	2	2	2	1	1	-	1	1	-	-	1
CO4	2	1	1	1	1	-	-	-	-	-	1
CO5	1	1	2	1	2	-	-	-	-	-	1
CO6	-	-	-	-	-	1	-	-	-	1	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	2	-	-	-
CO2	-	1	2	-
CO3	1	-	1	-
CO4	-	1	-	1
CO5	1	-	-	-
CO6	-	1	1	-

BIG DATA ANALYTICS

Course Code: EE-716

1. **Course Pre-requisites:**
   1. Basic programming (Python)
   2. Familiarity with databases (SQL)

2. **Course Learning Objectives:**

   This course explores big data fundamentals from an Electrical Engineering perspective, covering key characteristics (volume of sensor data, velocity of PMU streams, variety of grid datasets) and challenges (real-time processing, data quality). Students will study Hadoop/Spark for power system analytics, apply ML techniques for fault detection/load forecasting, and examine ethical implications of smart grid data usage through hands-on projects with real- world energy datasets.

3. **Course Name: BIG DATA ANALYTICS**
   Course Code: EE-716
   Hours per Week: 2
   Credits: 2

   Course Contents:

Module	Topics	30L
1.	**Introduction to Big Data:** Definition of big data and its 5 V's (Volume, Velocity, Variety, Veracity, Value) i. Smart meter data (Volume: Terabytes/day from grids) ii. Real-time sensor data from IoT devices (Velocity: Streaming data from substations)., Big Data Challenges in Electrical Systems: Scalability: Handling data from millions of smart meters (e.g., India's Smart Grid Mission). Real-time Processing: Challenges in Grid Stability Monitoring (e.g., Phasor Measurement Units (PMUs) generating over 30 samples/sec). Data Quality: Noise in sensor data (e.g., faulty IoT sensors in power lines). Privacy/Security: Cyber-physical risks in smart grids (e.g., False Data Injection Attacks).	5
2.	**Big Data Technologies**: Hadoop Ecosystem (HDFS, MapReduce, YARN): Challenges in power grid data: High-velocity PMU (Phasor Measurement Unit) data, smart meter logs (Volume), heterogeneous sources (Variety), storing time-series data (voltage, frequency, load profiles) in HDFS. Fault tolerance: Replicating substation sensor data across nodes. Dynamic resource allocation for real-time grid monitoring vs. batch processing,	5
3.	**Introduction to Big Data Processing:** Data Processing Paradigms, Batch vs. Stream Processing Case 1: Batch: Historical load forecasting (smart grids). Case 2: Real-time fault detection (PMU data). Hadoop MapReduce vs. Spark vs. Flink. Batch Processing with Spark, Spark RDDs & Data Frames, Resilient Distributed Datasets (RDDs) for fault tolerance. Case 1: Cleaning noisy sensor data (e.g., voltage spikes) and Calculate average load per substation. Stream Processing for Real-Time Analytics: Spark Streaming & Kafka, Windowing operations (e.g., 5-minute rolling averages). Case 1: Real-time frequency monitoring in power grids. Structured Streaming: Processing IoT device streams (e.g., smart thermostats). Performance Tuning & Case Studies: Optimisation Techniques, Partitioning strategies for grid data, Caching	5

	frequently used datasets (e.g., substation lookup tables), Case 1: Predictive maintenance using vibration and thermal data.	
4.	**Machine Learning for Big Data**: Algorithms and Tools (Scalability Issues): Parallelising ML Workloads: Data parallelism (e.g., parameter averaging in Spark), Model parallelism (e.g., deep learning on GPUs), Dimensionality Reduction for Big Data, PCA (Principal Component Analysis) on distributed datasets. Case study 1: Compressing PMU data for faster anomaly detection. Hyperparameter Tuning at Scale: Grid search with Spark's Cross Validator. Tools & Datasets. Tools: Spark MLlib, TensorFlow, scikit-learn (for comparison).	5
5.	**Big Data Visualisation and Interpretation**: Need of Visualization Matters in Big Data, Challenges: High dimensionality, real-time streaming, and scalability (Visualising smart meter data to detect consumption patterns) Types of Visualizations for Big Data Time-Series: Load profiles, voltage/frequency trends. Geospatial: Substation locations, fault heatmaps. Interactive Dashboards: Real-time monitoring (e.g., Tableau, Grafana). Visualizing High-Dimensional Data. PCA and Scatter Plots: Reducing PMU data dimensions, Comparing multiple sensor readings.	5
6.	**Ethical, Legal, and Societal Implications of Big Data**: Ethical Challenges in Big Data: Bias in Algorithms. Case study 1: Racial bias in energy allocation algorithms (e.g., "fairness" in smart meter pricing). Privacy vs. Utility, Accountability, Legal Frameworks: Indian Electricity Rules: Data ownership and sharing policies. Compare GDPR vs. India's Personal Data Protection Bill (PDPB) Societal Impacts & Mitigation: Big data exacerbates inequality in energy access. Environmental Costs: Carbon footprint of data centres processing grid data.	5

4. Text Books:

T1: T1: Big Data: Principles and Best Practices of Scalable Realtime Data Systems – Nathan Marz, Publisher: Manning Publications

T2: Hadoop: The Definitive Guide – Tom White, Publisher: O'Reilly Media

T3: Learning Spark: Lightning-Fast Data Analytics – Holden Karau et al., Publisher: O'Reilly Media

T4: Data Science from Scratch – Joel Grus, Publisher: O'Reilly Media

T5: NoSQL Distilled – Pramod J. Sadalage, Martin Fowler , Publisher: Addison-Wesley

5. References:

R1: Big Data Analytics: From Strategic Planning to Enterprise Integration – David Loshin, Publisher: Morgan Kaufmann (Elsevier).

R2: Designing Data-Intensive Applications – Martin Kleppmann, Publisher: O'Reilly Media.

R3: Python for Data Analysis – Wes McKinney, Publisher: O'Reilly Media.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the fundamentals of big data and its applications	Represent, Identify	Understand, Remember
CO2	Analyze and evaluate big data technologies like Hadoop and Spark.	Analyze, Evaluating	Understand, Apply, Evaluating

CO3	Apply machine learning techniques to big data problems	Understand, Analyze	Understand, Apply
CO4	Design solutions for big data processing and visualization.	Analyze, Evaluating	Understand, Apply, Analyze
CO5	Assess ethical and societal implications of big data.	Understand, Remember	Evaluate
CO6	Develop a project using big data tools to solve real-world problems.	Design	Create

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	2	-	2	-	-
4	-	-	3	-	-	-
5	-	-	-	3	-	-
6	-	-	-	-	3	1

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	-	-	1	-	-	-	-	-	-
CO2	-	3	-	-	2	-	-	-	-	-	-
CO3	3	-	2	1	-	-	-	-	-	-	-
CO4	-	-	3	-	2	-	-	-	-	-	-
CO5	-	-	-	-	-	3	-	2	-	-	-
CO6	-	-	-	-	-	-	-	-	3	2	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2
CO2	3	-	1	1
CO3	3	2	2	1
CO4	3	-	2	1
CO5	3	-	1	2
CO6	3	2	3	2

INTERNET OF THINGS

Course Code: EE-723

1. **Course Pre-requisites:**
   1. Basic Electronics & Embedded Systems
   2. Programming Skills (Python)
   3. Networking & Communication Protocols

2. **Course Learning Objectives:**
   To make students know the ecosystem of Internet of Things (IoT).
   To provide an understanding of the technologies and the standards relating to the Internet of Things.
   To develop skills in IoT technical planning.

3. **Course Name: INTERNET OF THINGS**
   Course Code: EE-723
   Hours per Week: 2
   Credits: 2

   Course Contents:

Module	Topics	30L
1.	**Introduction to Internet of Things**: IoT: Definition and importance, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Three-layer and Five-layer model of IoT	05
2.	**IoT Communication network**: Architecture of IoT, Communication network: Home Area Network (HAN), Neighborhood Area Network (NAN), Field Area Network (FAN), Wide Area Network (WAN), Wireless Sensor Networks (WSNs)	05
3	**IoT Protocols**: IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRa WAN, Network Layer: IP versions, Constrained Nodes and Constrained Networks, Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks, Application Transport Methods: Supervisory Control and Data Acquisition, Application Layer Protocols: CoAP and MQTT	05
4.	**IoT Sensors/Actuators, Devices and Challenges**: IoT Sensor Technology, Mobile Phone Based Sensors, Medical Sensors, Neural Sensors, Environmental and Chemical Sensors, Radio Frequency Identification, Actuators, Raspberry Pi as an IoT device, IoT Challenges: Design challenges, Development challenges, Privacy and Security challenges, Data Management and Other challenges	08
5.	**Application of IoT:** Smart Homes: Smart Appliances, Security and Safety. Smart Energy: Smart Meters, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), Real Time Pricing, Smart grid, Smart Cities: Smart Vehicles, Smart Lighting, Smart Parking etc.	05
6.	Case Studies and Real-world IoT Applications.	02

4. Text Books:

T1: Internet of Things By Rajkamal, Tata McGraw Hill publication.

T2: Internet of things(A-Hand-on-Approach) By Vijay Madisetti and ArshdeepBahga,1st Edition, Universal Press.

T3: The Internet of Things: Connecting Objects By Hakima Chaouchi Wiley publication.

T4: The Internet of Things – Key applications and Protocols By Olivier Hersent, David Boswarthick, Omar Elloumi, Wiley, 2012.

T5: Internet of Things: Architecture and Design Principles, Raj Kamal, McGraw Hill Education, 2017.

5. References:

R1: Research papers on IoT from IEEE/ACM journals.

R2: Official documentation of IoT platforms (e.g., Arduino, Raspberry Pi, AWS IoT).

R3: IoT standards and whitepapers from IETF and ITU.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the function blocks, three-layer model and five-layer model of IoT.	Represent, Identify	Understand, Remember
CO2	Analyze IoT protocols and communication technologies.	Analyze, Evaluating	Understand, Apply, Evaluating
CO3	Design IoT systems using sensors and actuators.	Understand, Analyze	Understand, Apply
CO4	Evaluate privacy, security and design-related challenges of IoT.	Analyze, Evaluating	Understand, Apply, Analyze
CO5	Demonstrate IoT applications through case studies.	Understand, Remember	Evaluate
CO6	Develop a prototype for a real-world IoT problem.	Design	Create

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	2	-	-	-	-
4	-	-	3	1	-	-
5	-	-	-	-	3	-
6	-	-	-	-	1	3

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	-	2	2	-	-	-	1
CO2	3	3	1	1	-	2	2	-	-	-	1
CO3	3	3	1	1	-	2	2	-	-	-	1
CO4	3	3	1	1	-	2	2	-	-	-	1
CO5	3	3	1	1	-	2	2	-	-	-	1
CO6	3	3	1	1	-	2	2	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	-	-	1	-
CO2	-	2	1	-
CO3	3	1	1	-
CO4	3	-	1	1
CO5	3	-	1	1
CO6	3	2	1	1

BLOCK CHAIN TECHNOLOGY

Course Code: EE-724

1. Course Pre-requisite: NIL

2. Course Learning Objectives:

To understand the building blocks of Blockchain. To the significance of Distributed Ledger Technology and Smart Contracts. To exploit applications of Blockchain in real-world scenarios and their impacts.

3. Course Name: BLOCK CHAIN TECHNOLOGY
Course Code: EE-724
Hours per Week: 2
Credits: 2

Course Contents:

Module	Topics	28L
1.	**Foundations of Blockchain:** Blockchain Architecture – Challenges – Applications – Blockchain Design Principles -The Blockchain Ecosystem - The consensus problem - Asynchronous Byzantine Agreement - AAP protocol and its analysis - peer-to-peer network – Abstract Models - GARAY model - RLA Model - Proof of Work (PoW) - Proof of Stake (PoS) based Chains - Hybrid models.	04
2.	**Distributed Ledger Technology** Origin of Ledgers – Types and Features of Distributed Ledger Technology (DLT) - Role of Consensus Mechanism - DLT Ecosystem - Distributed Ledger Implementations – Blockchain - Ethereum - Public and Private Ledgers – Registries – Ledgers - Practitioner Perspective: Keyless Technologies, Transparency as a Strategic Risk, Transparency as a Strategic Asset, Usage of Multiple IDs - Zero Knowledge Proofs - Implementation of Public and private Blockchain	04
3.	**Smart Contracts** Anatomy of a Smart Contracts - Life Cycle - Usage Patterns - DLT- based smart contracts -Use Cases: Healthcare Industry and Property Transfer	05
4.	**Decentralized Organization** Decentralization versus Distribution - Centralized-distributed (Ce-Di) organizations -Decentralized-distributed (De-Di) organizations	05
5.	**Types of Blockchain Ecosystem** One-Leader Ecosystem - Joint Venture or Consortia Ecosystems - Regulatory Blockchain Ecosystems - Components in Blockchain Ecosystem: Leaders, Core Group, Active Participants, Users, Third- Party Service Providers - Governance for Blockchain Ecosystems.	05
6.	**Blockchain Protocols**: Ethereum tokens – Augur - Golem - Understanding Ethereum tokens - App Coins and Protocol Tokens - Blockchain Token Securities Law Framework - Token Economy - Token sale structure - Ethereum Subreddit.	05

4. Text Books:

T1: Dhillon, V., Metcalf, D., and Hooper, M, Blockchain-enabled applications, 2017, 1st Edition, CA: Apress, Berkeley.

5. References:

R1: Distributed Ledger Technology: The Science of the Blockchain, Wattenhofer, R. P, (Inverted Forest Publishing), 2017, 2nd Edition, Createspace Independent Pub, Scotts Valley, California, US

R2: Blockchain Architecture Design And Use Cases, Prof. Sandip Chakraborty, Dr. Praveen Jayachandran, [MOOC], NPTEL: https://nptel.ac.in/courses/106/105/106105184/

R3: Blockchains, digital assets, smart contracts, decentralized autonomous organizations, Diedrich, H., Ethereum, 2016, 1st Edition, Wildfire Publishing, Sydney.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Students will be able to analyze the fundamental structure of blockchain systems, identify key design principles, and understand the challenges in blockchain architecture, including consensus mechanisms and the role of peer-to-peer networks.	Analyze, Identify	Understand, Remember
CO2	Students will comprehensively understand Distributed Ledger Technology (DLT), its various types, and how it supports blockchain ecosystems. They will be able to distinguish between public and private ledgers, Ethereum, and other distributed ledger implementations, and evaluate their applications in various industries.	Identify, Select	Understand, Apply, Analyze
CO3	Students will be able to critically evaluate different consensus mechanisms such as Proof of Work (PoW), Proof of Stake (PoS), and hybrid models, and apply them to different blockchain ecosystems. They will also explore key blockchain protocols such as Ethereum tokens and understand the functionality and regulation of blockchain-based token systems.	Identify, Select	Understand, Apply
CO4	Students will learn the anatomy and lifecycle of smart contracts, including their design and implementation on distributed ledger technologies. They will be able to identify key use cases of smart contracts in sectors such as healthcare and property transfer, and understand their role in blockchain applications.	Analyze	Understand, Apply, Analyze
CO5	Students will understand the differences between decentralized and distributed organizations, identify various blockchain ecosystem models such as one-leader ecosystems and consortia ecosystems, and explore governance and the roles of participants in blockchain ecosystems.	Identify	Analyze

CO6	Students will acquire the skills to analyze the token economy and the legal framework surrounding blockchain tokens, including the structure of token sales, token securities law, and Ethereum-based tokens. They will understand the impact of blockchain tokenomics on real-world applications, especially in regulatory environments.	Implement	Evaluate

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	1	3	-	-	-	-
3	1	1	3	-	-	-
4	1	1	1	-	-	3
5	1	-	-	-	-	-
6	1	-	-	3	-	-

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	2	1	2				
CO2	2	3	2	2	2	2	2				
CO3	2	3	3	2	3	2	2				
CO4	2	2	2	2	2	2	2				
CO5	2	2	2	3	2	2	2				
CO6	2	2	2	2	1	3	2	1	1	1	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	2	1	2
CO3	3	3	1	2
CO4	2	3	1	1
CO5	2	2	1	1
CO6	3	3	1	2

CLOUD COMPUTING

Course Code: EE-725

1. Course Pre-requisite:

1. Computer Fundamentals and Operating Systems
2. Basic Networking Concepts
3. Introduction to Web Technologies
4. Basic Programming
5. Database Fundamentals

2. Course Learning Objectives:

The objectives of studying embedded systems are to understand the fundamental principles of designing and implementing embedded hardware and software. This includes gaining insight into how firmware and operating systems interact with hardware, ensuring efficient and reliable system performance. Students will explore resource management, real-time processing, and optimization techniques to design systems that meet specific functional and operational requirements. The goal is to equip learners with the skills needed to create robust embedded systems used in various applications across industries.

3. Course Name: CLOUD COMPUTING
Course Code: EE-725
Hours per Week: 2
Credits: 2

Course Content:

Module	Topics	30L
1.	**Introduction to Cloud Computing:** Overview and history of cloud computing, essential characteristics and service models, Deployment models: Public, private, hybrid, and community cloud.	05
2.	**Cloud Architecture and Infrastructure:** Cloud computing architecture, Virtualization technologies: Types, hypervisors, benefits, Storage and network virtualization, Data centres and infrastructure management.	06
3.	**Cloud Computing Services and Platforms):** Cloud service providers: AWS, Azure, Google Cloud, Services offered: Computing, storage, databases, networking, Cloud APIs and SDKs, Cloud development platforms.	06
4.	**Security in Cloud Computings):** Cloud security fundamentals, Identity and access management (IAM), Data privacy and compliance, Security challenges and solutions.	05
5.	**Cloud Applications and Case Studies:** Industrial applications and real- world case studies, Smart grids and power system management using cloud computing, IoT integration with cloud services.	04
6.	**Future Trends and Research Directions;** Edge computing and fog computing, Green cloud computing, Challenges, limitations, and future research trends.	04

4. Text Books:

T1: Mastering Cloud Computing: Foundations and Applications Programming, Rajkumar Buyya, Christian Vecchiola, and S Thamarai Selvi, Morgan Kaufmann, 2013.
T2: Cloud Computing: Concepts, Technology & Architecture, Thomas Erl, Ricardo Puttini, Zaigham, Mahmood, Prentice Hall, 2013.
T3: The Cloud Computing Book: The Future of Computing Explained, Douglas Comer, Chapman and Hall/CRC, 2023.

5. References:

R1. Cloud Computing: Architecting Next-Gen Transformation Paradigms, 4ed Kumar Saurabh, Wiely, 2017.
R2. Cloud Computing: Theory and Practice, Dan C. Marinescu, Morgan Kaufmann, 2017.
R3. Cloud Computing: Implementation, Management, and Security, John W Rittinghouse and James F. Ransome, CRC Press, 2016.
R4. Cloud Computing, SaaS, PaaS, IaaS, Virtualization, Business Models, Mobile, Security and More, Kris Jamsa, Jones & Bartlett Learning, 2013.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Clearly understand fundamental concepts, characteristics, and deployment models of cloud computing.	Understand	Understand
CO2	Demonstrate knowledge of cloud architecture, virtualization technologies, and infrastructure management.	Analyze	Analyze
CO3	Utilize popular cloud platforms (AWS, Azure, Google Cloud) for various services like computing, storage, databases, and networking.	Evaluate, Implement	Apply & Evaluate
CO4	Identify and mitigate security challenges, ensuring data privacy and compliance in cloud environments.	Apply	Apply
CO5	Evaluate and implement cloud solutions for real-world applications, specifically in electrical engineering domains such as smart grids and IoT.	Implement	Apply
CO6	Explore and critically analyze future trends, such as edge computing, fog computing, and sustainability aspects of cloud computing.	Predict	Analyze

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	1	0	1	0
2	2	3	1	1	1	0
3	1	2	3	1	1	1
4	1	1	1	3	1	1
5	1	1	2	1	3	1
6	0	1	1	1	1	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	2	2	1	1	2	1	3
CO2	3	3	2	3	3	2	1	1	2	1	3
CO3	3	3	3	2	3	2	1	1	2	2	3
CO4	3	3	3	2	3	3	3	2	2	1	3
CO5	2	2	2	2	2	2	2	1	2	1	3
CO6	2	2	1	2	2	3	3	2	2	2	3

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	-
CO2	3	3	2	-
CO3	3	3	2	-
CO4	2	3	3	-
CO5	2	2	2	-
CO6	2	2	3	-

DIGITAL TWIN TECHNOLOGY
Course Code: EE-726

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1. Course Pre-requisite:

a. Basics of IoT (Internet of Things)
b. Fundamentals of Data Communication and Networking
c. Basic Programming Skills
d. Introduction to Modeling & Simulation
e. Basic Data Analytics and Machine Learning

2. Course Learning Objectives:

The objectives of studying digital twins are to understand the fundamentals of Digital Twin (DT) systems. This includes gaining knowledge architecture, components, and lifecycle. They are able to apply DT in sectors like manufacturing, energy, healthcare, smart cities. They will learn modeling, simulation, real-time monitoring, and AI/ML integration. The goal is to implement a mini DT project using IoT, simulation, and cloud tools.

3. Course Name: DIGITAL TWIN TECHNOLOGY
Course Code: EE-726
Hours per Week: 2
Credits: 2

Course Content:

Module	Topics	30L
1.	**Introduction to Digital Twin:** Definition, history, and evolution of Digital Twins, Basic components: physical entity, virtual representation, and data connections, Application areas and industrial significance.	05
2.	**Technologies for Digital Twin:** IoT fundamentals, Cloud computing and edge computing basics, Big data analytics and AI integration, Communication technologies.	05
3.	**Modeling and Simulation:** Basic modeling principles and digital representation, Physics-based modeling and simulation, Data-driven modeling techniques, Hybrid modelling approaches.	06
4.	**Digital Twin Implementation:** Design and architecture of Digital Twin systems, Integration with real-time systems and sensor data, Case studies from power systems, smart grids, and industrial automation, Cybersecurity in Digital Twin implementations.	06
5.	**Real-Time Monitoring and Predictive Maintenance:** Real-time analytics and visualization techniques, Predictive maintenance using digital twins, Fault detection, diagnostics, and prognostics.	04
6.	**Future Trends and Challenges:** Ethical, social, and economic implications, Challenges and barriers in implementation, Emerging trends and research opportunities.	04

4. Text Books:

T1: Digital Twin Technologies and Smart Cities, Seshadri, Arvind, CRC Press, 2022.
T2: Digital Twin Driven Smart Design, Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, Academic Press, 2020.
T3: Digital Twin Technology: Fundamentals and Applications, Manisha, Vohra, John Wiley & Sons, 2022.

5. References:

R1. Digital Twin Driven Smart Manufacturing, Tao, Fei, Zeng, Meng, Nee, A.Y.C. Academic Press, 2019.
R2. Digital Twin Technology: Fundamentals and Applications, Orhan Korhan Fausto Pedro García Márquez, 2023, DOI: 10.5772/intechopen.104048.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand and articulate the concept, architecture, and components of Digital Twin technologies.	Understand, Articulate	Understand
CO2	Analyze and implement fundamental technologies such as IoT, AI, cloud computing, and data analytics integral to digital twins.	Analyze, Implement	Apply & Analyze
CO3	Develop proficiency in modeling and simulating digital twins using physics-based, data-driven, and hybrid modeling approaches.	Develop, Simulate	Apply
CO4	Evaluate real-world implementations of digital twins in electrical engineering domains such as power systems, smart grids, and industrial automation.	Evaluate	Evaluate
CO5	Apply techniques for real-time monitoring, predictive maintenance, and fault diagnosis using digital twin frameworks.	Apply, Diagnose, Detect	Apply
CO6	Demonstrate awareness of ethical considerations, cybersecurity issues, and future research opportunities in the field of digital twins.	Demonstrate awareness	Understand

7. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	1	1	0	0
2	2	3	1	2	1	1
3	1	1	3	2	1	0
4	1	2	2	3	2	1
5	0	1	1	2	3	1
6	1	1	0	1	1	3

8. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	1	2	2	1	2	2	1	3
CO2	3	3	2	2	3	2	1	1	2	1	3
CO3	3	2	3	3	3	1	1	1	1	1	3
CO4	3	3	3	3	3	2	1	2	2	2	3
CO5	3	3	2	3	3	1	1	1	1	1	3
CO6	2	1	1	1	2	3	3	2	2	2	3

9. Mapping to PSO

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-
CO2	3	3	2	-
CO3	3	3	-	-
CO4	3	3	2	-
CO5	3	3	2	-
CO6	-	2	3	-

ELECTRIC AND HYBRID VEHICLES LAB

Course Code: EE-791

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1. Course Prerequisite:

1. Electric and Hybrid Vehicle
2. Power Electronics Lab
3. Electrical Machines Lab

2. Course Learning Objectives:

This course is designed to provide hands-on experience with electric and hybrid vehicle components, systems, and control strategies through laboratory experiments. Students will learn to identify, test, and analyze various EV/HEV subsystems including battery management, motor drives, energy storage, and charging systems. The course emphasizes both hardware implementation and software simulation of electric vehicle systems using MATLAB/Simulink.

3. Course Name: Electric and Hybrid Vehicles Lab

Course Code: EE-791
Hours per Week: 2
Credits: 1

Course Content:

Experiment No	Type: Hardware/Software	Topics
1	Hardware	Study of Lead-acid and Li-ion battery characteristics and State of Charge (SOC) estimation
2	Software	Battery modeling and simulation using MATLAB/Simulink for different driving cycles
3	Hardware	Study of BLDC motor characteristics and speed-torque curves for EV applications
4	Software	BLDC motor control simulation using MATLAB with different control strategies
5	Hardware	Study of DC motor speed control using PWM for electric vehicle drive system
6	Software	EV powertrain modeling and simulation using MATLAB/Simulink

7	Hardware	Study of solar panel characteristics and MPPT for EV charging applications
8	Software	Energy management system simulation for hybrid electric vehicles using MATLAB
9	Hardware	Study of regenerative braking system and energy recovery analysis
10	Software	Vehicle dynamics simulation and performance analysis using MATLAB
11	Hardware	Study of EV charging circuit and power factor correction
12	Software	EV charging system analysis and optimization using MATLAB/Simulink

4. Text Books:

T1. Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley.

T2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, CRC Press, 2004.

T3. Electric and Hybrid Vehicles, Iqbal Husain, CRC Press.

T4. Modeling for Hybrid and Electric Vehicles Using Simscape, Shuvra Das, Morgan and Claypool publishers.

5. References:

R1. Electric and Hybrid Electric Vehicles, James D. Halderman & Curt Ward, Pearson.

R2. Battery Management Systems for Large Lithium-Ion Battery Packs, Davide Andrea, Artech House.

R3. Electric Vehicle Machines and Drives: Design, Analysis and Application, Chang-Ming Liaw, Wiley-IEEE Press.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Identify appropriate components and instruments for EV/HEV experiments	Identify	Remember
CO2	Test and analyze battery systems, motor drives, and charging circuits for electric vehicles	Test, Analyze	Apply, Analyze
CO3	Construct and implement EV subsystem circuits with appropriate safety measures	Construct	Apply
CO4	Validate performance characteristics of EV components and energy management systems	Validate	Analyze, Evaluate

CO5	Demonstrate modeling and simulation of electric vehicle systems using MATLAB/Simulink	Demonstrate	Understand, Apply
CO6	Work effectively in a team for complex EV system development and testing	Work	Evaluate, Create

7. Mapping of course outcomes to unit / course content:

Experiment no.	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
1-2	3	3	3	3	3	2
3-4	3	3	3	3	3	2
5-6	3	3	3	3	3	2
7-8	3	3	3	3	3	2
9-10	3	3	3	3	3	2
11-12	3	3	3	3	3	2

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	3	2	1	-	2	2	2
CO2	3	3	3	3	3	2	2	1	2	2	2
CO3	3	3	3	3	3	2	2	1	2	2	2
CO4	3	3	3	3	3	2	2	1	3	2	3
CO5	3	3	3	3	3	2	1	1	3	2	3
CO6	2	2	2	2	2	2	3	3	3	3	2

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1
CO2	3	3	3	2
CO3	3	3	2	2
CO4	3	3	3	3
CO5	3	3	3	2
CO6	2	2	2	3

ANDROID APP DEVELOPMENT LAB

Course Code: EE-792

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1. Course Prerequisite:

1. Object Oriented Programming
2. Data Structures and Algorithms
3. Database Management Systems

2. Course Learning Objectives:

This laboratory course is designed to provide hands-on experience in developing Android applications using modern development tools and techniques. The course covers fundamental concepts of mobile app development, user interface design, data management, networking, and integration with device sensors. Students will gain practical experience in developing complete Android applications from concept to deployment. Focus areas include Android Studio IDE, Java/Kotlin programming for Android, UI/UX design, database integration, API consumption, and utilizing device hardware features.

3. Course Details:

Course Name: ANDROID APP DEVELOPMENT LAB
Course Code: EE-792
Hours per Week: 2
Credits: 1

Lab Experiments Details:

Exp No.	Type	Topics
1	Software	**Android Development Environment Setup & First Application:** Installation and configuration of Android Studio IDE, SDK setup, understanding project structure, creating first Android application, running apps on emulator and physical devices, debugging techniques
2	Software	**Comprehensive UI Design & Layout Management:** Study of different layout types (Linear Layout, Relative Layout, Constraint Layout), creating responsive user interfaces with TextView, EditText, Button, ImageView, styling and theming
3	Software	**Advanced List Views & Custom Adapters:** Implementation of RecyclerView and ListView with custom adapters for dynamic content display, data binding techniques
4	Software	**Fragments, Navigation & Custom Components:** Working with fragments,

Exp No.	Type	Topics
		navigation patterns, creating custom UI components, and implementing modern navigation architecture
5	Software	**Activity Lifecycle & Multi-Activity Navigation:** Study of Activity lifecycle, creating multiple activities, Intent-based data passing, and implementation of proper navigation flow and activity state management
6	Software	**Local Storage Solutions:** Implementation of Shared Preferences for user preferences, internal/external storage operations, file I/O operations, and efficient data management techniques
7	Software	**SQLite Database Integration:** Working with SQLite database, creating schemas, implementing CRUD operations, and database optimization techniques
8	Software	**Room Persistence Library & Advanced Data Management:** Implementation of Room persistence library, advanced data binding techniques, and modern Android data architecture patterns
9	Software	**RESTful API Integration & JSON Processing:** Consuming RESTful APIs using Retrofit/Volley, parsing JSON responses, handling HTTP requests and responses
10	Software	**Network Security & Offline Data Management:** Implementation of network security, handling offline scenarios, web service integration, and data synchronization strategies
11	Hardware	**Device Sensors & Hardware Integration:** Integration with device sensors (accelerometer, gyroscope, GPS), camera functionality, location-based services, and hardware feature utilization
12	Software	**Comprehensive Android Project:** Development of a complete Android application integrating multiple concepts including UI design, data management, networking, and sensor integration

4. Text Books:

T1. Android Programming: The Big Nerd Ranch Guide, Bill Phillips, Chris Stewart, Kristin Marsicano, Big Nerd Ranch, 4th Edition.

T2. Head First Android Development, Dawn Griffiths, David Griffiths, O'Reilly Media, 2nd Edition.

T3. Android Application Development All-in-One For Dummies, Barry Burd, Wiley, 3rd Edition.

T4. Professional Android, Reto Meier, Ian Lake, Wrox, 4th Edition.

5. Reference Books:

R1. Android Development with Kotlin, Marcin Moskala, Igor Wojda, Packt Publishing.
R2. Learning Java by Building Android Games, John Horton, Packt Publishing, 3rd Edition.
R3. Android UI Development with Jetpack Compose, Thomas Künneth, Packt Publishing.
R4. Reactive Programming with RxJava, Tomasz Nurkiewicz, Ben Christensen, O'Reilly Media.
R5. Android Security Internals, Nikolay Elenkov, No Starch Press.
R6. Building Android Apps with HTML, CSS, and JavaScript, Jonathan Stark, O'Reilly Media.
R7. Pro Android Games, Vladimir Silva, A press.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Install and configure Android development environment and create basic Android applications.	Install, Configure, Create	Remember, Apply
CO2	Design and implement responsive user interfaces using various Android layout managers and UI components.	Design, Implement	Create, Apply
CO3	Develop applications with multiple activities and proper navigation flow using Intents and lifecycle management.	Develop, Manage	Create, Analyze
CO4	Implement local data storage solutions using Shared Preferences, file systems, and SQLite databases.	Implement, Store	Apply, Create
CO5	Integrate web services and APIs into Android applications for data exchange and networking functionality.	Integrate, Exchange	Apply, Analyze
CO6	Utilize device sensors and hardware features to create feature-rich mobile applications.	Utilize, Create	Apply, Evaluate

7. Mapping of course outcomes to module / course content:

Experiment No.	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	-	-	-	-
2	2	3	-	-	-	-
3	2	3	1	-	-	-
4	2	3	2	-	-	-
5	2	2	3	-	-	-

Experiment No.	CO1	CO2	CO3	CO4	CO5	CO6
6	2	1	2	3	-	-
7	2	-	2	3	-	-
8	2	2	2	3	1	-
9	2	1	2	2	3	-
10	2	2	2	2	3	1
11	2	2	2	1	2	3
12	3	3	3	3	3	3

8. Mapping of the Course outcomes to Program Outcomes:

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	1	1	-	3	-	1	-	1	1	2
CO2	3	2	3	1	3	2	2	1	2	1	2
CO3	3	2	3	2	3	1	2	2	2	2	2
CO4	3	2	2	2	3	2	2	1	2	1	2
CO5	3	3	2	2	3	2	2	2	2	2	3
CO6	3	3	3	3	3	3	2	2	2	2	3

9. Mapping to PSO:

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1
CO2	3	3	2	2
CO3	3	3	2	2
CO4	3	2	2	2
CO5	3	3	2	2
CO6	3	3	2	3