DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ANNA UNIVERSITY, CHENNAI – 25

VISION:

The vision of the department is to produce analytically proficient and technologically competent Electrical and Electronics Engineers who can serve and take forward the academic, industry and research organizations to newer heights and be effective for building the nation.

MISSION:

- To impart high quality technical education with the state of the art laboratory practice.
- To provide conducive academic ambience to enable best teaching and learning processes.
- To generate resources through research and consultancy projects for pursuing research and developmental activities in emerging areas.
- To associate with academic and industrial organizations for research activities to develop and provide vital and viable solutions for social needs indigenously.
- To develop leadership skills in students with high degree of ethics, morals and values and instill confidence to lead the organization.

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. POWER ENGINEERING AND MANAGEMENT
REGULATION – 2023
CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABUS I TO IV SEMESTERS

1. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I.	To produce graduates with domain knowledge in Power Engineering and Power Business Management who are employable in Core Power engineering, Energy Marketing and Auditing related public and private organisations.
II.	To motivate the graduates to take up entrepreneurship as career / pursue research to identify and actively participate in energy management, power trading and be part of renewable energy-based power plants and its service industries.
III.	To make students evolve themselves as a consultant and provide solutions to the practical problems faced by power industries.

2. PROGRAM OUTCOMES (POs)

On Successful Completion of the programme, the graduate would have:	
PO1	The ability to independently carry out research/investigation and development work to solve practical problems.
PO2	The ability to write and present a substantial technical report/document.
PO3	The ability to demonstrate a degree of mastery in power management towards monitoring and analysis of renewable energy based power plants and energy related equipment.
PO4	The ability to Model and analyse the renewable energy systems with energy storage technology using electrical computation software.
PO5	The ability to perform experiments, understand the power management principles and apply these to lead a team, manage the power projects and work in multidisciplinary environments.
PO6	The ability to recognize the need for energy conservation and sustainability development and have the preparation to engage in independent and life-long learning towards product development.

. MAPPING OF PEOs with POs

PEO	PO					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
I.	3	1	2	2	3	3
II.	3	2	3	3	3	3
III.	3	2	3	1	2	3

Attested

Mapped with 1, 2, 3 & -, scale: 1-low ; 2-medium ; 3-high

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PROGRAMME ARTICULATION MATRIX

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6
YEAR 1	Semester 1	Energy Conservation and Sustainable Development	2	1	2	-	1	2
		Research Methodology and IPR	3	1	-	-	-	2
		Modern Power System Engineering	2	1	3	-	3	1
		Power Business Management	1	3	1	-	2	1
		Electric Vehicle Charging Infrastructure	3	1	1	-	2	3
		Professional Elective I	-	-	-	-	-	-
		Power Engineering Laboratory	2	1	2	3	2	-
		Electric Vehicle Laboratory	3	2	1	3	2	-
	Semester 2	Energy Management and Audit	2	1	2	-	3	2
		Operations Management	2.8	3	1.5	1	1.6	3
		Optimization Techniques for Energy Management	3	1	1	2	2	1
		Energy Storage Systems	2	1	3	-	1	2
		Professional Elective II	-	-	-	-	-	-
		Professional Elective III	-	-	-	-	-	-
		Energy Audit Laboratory	2	1	3	3	-	1
		Summer Internship* / Mini Project	-	-	-	-	-	-
YEAR 2	Semester 3	Professional Elective IV	-	-	-	-	-	-
		Professional Elective V	-	-	-	-	-	-
		Professional Elective VI	-	-	-	-	-	-
		Project Work I	-	-	-	-	-	-
	Semester 4	Project Work II	-	-	-	-	-	-

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REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PW3152	Energy Conservation and Sustainable Development	FC	3	0	0	3	3
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	PW3101	Modern Power System Engineering	PCC	3	0	0	3	3
4.	PW3102	Power Business Management	PCC	3	0	0	3	3
5.	PW3151	Electric Vehicle Charging Infrastructure	PCC	3	0	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICALS								
7.	PW3111	Power Engineering Laboratory	PCC	0	0	4	4	2
8.	PW3112	Electric Vehicle Laboratory	PCC	0	0	4	4	2
		TOTAL		**17**	**1**	**8**	**26**	**22**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	PW3201	Energy Management and Audit	PCC	3	0	0	3	3
2.	BA3251	Operations Management	PCC	3	1	0	4	4
3.	PW3252	Optimization Techniques for Energy Management	PCC	3	0	0	3	3
4.	PW3251	Energy Storage Systems	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	PW3211	Energy Audit Laboratory	PCC	0	0	4	4	2
8.	PW3212	Summer Internship* / Mini Project	EEC	*	*	*	*	2
		TOTAL		**18**	**1**	**4**	**23**	**23**

Note: * - The Summer Internship has to be carried out in core industries during the 2nd semester vacation.
- Minimum period of training = 4 weeks.

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
4.	PW3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	PW3411	Project Work II	EEC	0	0	24	24	**12**
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 72

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FOUNDATION COURSES (FC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	PW3152	Energy Conservation and Sustainable Development	3	0	0	3	1

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	3	

PROFESSIONAL CORE COURSES (PCC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	PW3101	Modern Power System Engineering	3	0	0	3	1
2.	PW3102	Power Business Management	3	0	0	3	1
3.	PW3151	Electric Vehicle Charging Infrastructure	3	0	0	3	1
4.	PW3111	Power Engineering Laboratory	0	0	4	2	1
5.	PW3112	Electric Vehicle Laboratory	0	0	4	2	1
6.	PW3201	Energy Management and Audit	3	0	0	3	2
7.	BA3251	Operations Management	3	1	0	4	2
8.	PW3252	Optimization Techniques for Energy Management	3	0	0	3	2
9.	PW3251	Energy Storage Systems	3	0	0	3	2
10.	PW3211	Energy Audit Laboratory	0	0	4	2	2
		TOTAL				28	

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PROFESSIONAL ELECTIVE COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PW3001	Distribution System and Automation	PEC	3	0	0	3	3
2.	PW3002	Hybrid Power and Energy Systems	PEC	3	0	0	3	3
3.	PW3051	Design and Modelling of Solar PV Systems	PEC	3	0	0	3	3
4.	PW3003	SCADA System and Applications Management	PEC	3	0	0	3	3
5.	PW3054	Grid Integration of Renewable Energy Sources	PEC	3	0	0	3	3
6.	PW3058	Waste to Energy Conversion	PEC	3	0	0	3	3
7.	PW3055	IOT for Smart Power Systems	PEC	3	0	0	3	3
8.	PW3057	Renewable Energy Technology	PEC	3	0	0	3	3
9.	PW3053	Energy Efficient Buildings	PEC	3	0	0	3	3
10.	PW3056	Micro Grid Operation and Control	PEC	3	0	0	3	3
11.	PW3052	Electric Vehicles and Power Management	PEC	3	0	0	3	3

PROFESSIONAL ELECTIVES COURSES (PEC)

(OFFERED BY OTHER P.G. PROGRAMMES)

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	ET3055	Embedded Networking and Automation of Electrical System	PEC	3	0	0	3	3
2.	ET3067	Unmanned Aerial Vehicle	PEC	3	0	0	3	3
3.	ET3054	Embedded Controllers for EV Applications	PEC	3	0	0	3	3
4.	ET3059	Intelligent System Design	PEC	3	0	0	3	3
5.	ET3052	Block chain Technologies	PEC	3	0	0	3	3
6.	ET3051	Big Data Analytics	PEC	3	0	0	3	3
7.	ET3251	Automotive Embedded Systems	PEC	3	0	0	3	3
8.	CO3054	Intelligent Transportation Systems	PEC	3	0	0	3	3
9.	CO3059	Wireless Sensor Networks	PEC	3	0	0	3	3
10.	PS3052	Distributed Generation and Micro Grid	PEC	3	0	0	3	3
11.	PS3252	Smart Grid	PEC	3	0	0	3	3
12.	PS3054	Wind Energy Conversion Systems	PEC	3	0	0	3	3
13.	PE3151	Analysis of Power Converters	PEC	3	0	0	3	3
14.	PE3053	Power Quality	PEC	3	0	0	3	3
15.	HV3052	Electromagnetic Interference and Compatibility	PEC	3	0	0	3	3
16.	HV3051	Design of Substations	PEC	3	0	0	3	3
17.	HV3152	Electromagnetic Field Computation and Modelling	PEC	3	0	0	3	3
18.	MA3156	Applied Mathematics for Electrical Engineers	PEC	4	0	0	4	4
19.	MA3159	Numerical Methods and Optimization Techniques	PEC	4	0	0	4	4

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	PW3212	Summer Internship*/ Mini Project	0	0	0	2	2
2.	PW3311	Project Work I	0	0	12	6	3
3.	PW3411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	20	

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SUMMARY

S.No.	Name of the Programme: M.E POWER ENGINEERING AND MANAGEMENT					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	3	-	-	-	3
2.	PCC	13	15	-	-	28
3.	PEC	3	6	9	-	18
4.	RMC	3	-	-	-	3
5.	EEC	-	2	6	12	20
	TOTAL CREDIT	**22**	**23**	**15**	**12**	**72**

PW3152 ENERGY CONSERVATION AND SUSTAINABLE DEVELOPMENT **L T P C**
3 0 0 3

UNIT I ENERGY CONSERVATION AND ENERGY EFFICIENCY IN ELECTRICAL SYSTEMS 9

Energy Conservation (EC): Importance of EC – Electrical System: Cascade Efficiency – Electricity Billing - Tariff Structure – Demand Curve - Power Factor (PF) and True Power Factor – Power Factor Correction Methods – Cost Benefits of PF Improvement –Performance Assessment of PF Capacitors – Demand Side Management (DSM).

UNIT II TRANSFORMERS AND MOTORS 9

Transformer: Basics - Types – Transformer Losses and Efficiency – Voltage Fluctuation Control: Off-Circuit Tap Changer and OLTC – Energy Efficient Transformers – Standards and Labelling for Distribution Transformers - Motors: Types - Characteristics – Efficiency - Motor selection – Factors affecting Energy Efficiency in Motors - Effects of rewinding – Need for Variable Frequency Drive (VFD) – Operating Principle of VFD - Energy Efficient (EE) Motors -– Star Labelling of EE Induction Motors.

UNIT III HVAC AND REFRIGERATION SYSTEM 9

Introduction – Types of Refrigeration system – Factors affecting performance and energy efficiency of refrigeration plants – Heat pumps and their applications – Ventilation systems - Standards and Labelling of room air conditioners – Energy saving opportunities.

UNIT IV LIGHTING SYSTEM 9

Introduction – Terms in Lighting System - Lamp types – Recommended Illuminance Levels – selection and application – ENCON opportunities – Energy Efficient Lighting Controls: Time Based Control – Occupancy Sensor.

UNIT V SUSTAINABLE DEVELOPMENT - CASE STUDIES 9

Introduction to Sustainable Development – Need for Sustainable Development – Importance of Sustainable Development – Pillars of Sustainable Development – Goals of Sustainable Development – Global, Regional and Community initiatives for Sustainable Development – Need for CO_2 Mitigation– – Introduction to PAT Scheme - Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Know the importance of Energy Conservation and Energy Efficiency in Electrical Systems.
CO2: Learn the various measures for energy conservation in transformers and motors.
CO3: Understand the energy efficiency in Refrigeration systems.
CO4: Design effective lighting systems.
CO5: Acquire the concept of goals towards Sustainable Development and PAT scheme.

REFERENCES:

1. Yacov Y. Haimes, Marguerite A. H Ruffner, "Energy Auditing and Conservation: Methods, Measurements, management and Case Studies", Taylor & Francis Inc, 1980.
2. "Energy Efficiency in Electrical Utilities", Third Edition, Bureau of Energy Efficiency (BEE), India, 2010.

3. Jack J. Kraushaar, Robert A. Ristenen, “Energy and Problems of a Technical Society”, Second Edition, Wiley, 1993.
4. Detlef Stolten, Viktor Schere, “Transition to Renewable Energy Systems”, First Edition, Wiley, 2013.
5. Charles M. Gottschalk, “Industrial Energy Conservation”, First Edition, Wiley, 1996.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	-	1	2
CO2	2	1	2	-	1	2
CO3	2	1	2	-	1	2
CO4	2	1	2	-	1	2
CO5	2	1	2	-	1	2
Average	**2**	**1**	**2**	**-**	**1**	**2**

RM3151 RESEARCH METHODOLOGY AND IPR **L T P C**
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for wring thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, "Research methodology for natural sciences", IISc Press, Kolkata, 2022,
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

PW3101 MODERN POWER SYSTEM ENGINEERING LT P C
3 0 0 3

UNIT I POWER FLOW ANALYSIS 9

Problem Formulation: Review of NR method, Fast Decoupled Load Flow – DC Load Flow Model – Distribution Load Flow: Ladder Iterative Technique, three phase load flow solutions

UNIT II STATE ESTIMATION 9

Introduction–Maximum Likelihood Weighted Least Squares Estimation–State Estimation of an AC Network– State Estimation by Orthogonal Decomposition – Use of Phasor Measurement Units – Applications of Power Systems State Estimation

UNIT III POWER SYSTEM SECURITY 9

Introduction–Factors Affecting Power System Security – Contingency Analysis: Generation outages, Transmission outages – Linear Sensitivity Factors – Voltage Collapse

UNIT IV POWER SYSTEM PROTECTION 9

Introduction to Power System Protection– Operating principles and Relay Construction – Overcurrent Protection– Microprocessor based Overcurrent Relays

UNIT V VOLTAGE STABILITY **9**

Single-Load Infinite-Bus System– Maximum Deliverable Power– Power-Voltage Relationships– Generator Reactive Power Requirement– Instability Mechanisms– Effect of Compensation– VQ Curves.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Carry out power flow analysis for transmission and distribution network.
CO2: Compute the state of the power system.
CO3: Carry out contingency analysis to analyze the power system security.
CO4: Understand over current protection for system security.
CO5: Analyze the concept of voltage stability.

REFERENCES:

1. J. J. Grainger, W. D. Stevenson, "Power System Analysis", First Edition, McGraw-Hill, 1994
2. Badri Ram, D. N. Vishwakarma, "Power System Protection and Switchgear", Third Edition, McGraw-Hill, 2022
3. T. V. Cutsem, C. Vournas, 'Voltage Stability of Electric Power Systems', First Edition, Springer, 1998
4. A. J. Wood, B. F. Wollenberg, G. B. Sheblé, "Power Generation Operation and Control", Third Edition, John Wiley and sons, 2013.
5. D P Kothari, I J Nagrath, R K Saket, "Modern Power System Analysis", McGraw-Hill, Fifth Edition, 2022.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	3	1
CO2	2	1	3	-	3	1
CO3	2	1	3	-	3	1
CO4	2	1	3	-	3	1
CO5	2	1	3	-	3	1
Average	**2**	**1**	**3**	**-**	**3**	**1**

PW3102 **POWER BUSINESS MANAGEMENT** **LT P C**
3 0 0 3

UNIT I POWER MANAGEMENT IN INDIA 9

Growth of Power Industry in India, Organizational Structure of central and state companies and its major roles and regulations, Power scenario in India, Load management in power sector, Grid Management, Development of power projects in India vs. demand study, Management of Electricity Demand Scenario in TamilNadu (TN) state and India, Load and Energy Management System - **Case Study**: Power demand study in state, Load management study in state.

UNIT II ACT AND REGULATORY COMMISSIONS 9

Introduction to the Power Scenario, Overview of the Indian Electricity Act 1910, Electricity Supply Act 1948, Electricity Regulatory Commissions Act 1998, Energy Conservation Act 2001, Energy Conservation (Amendment) Act, 2010, The Electricity Act 2003, Electricity Grid Code, State Electricity Regulatory Commission (SERC), Central Electricity Regulatory commission (CERC), Tribunal, Electricity Regulatory and Industry Structure in India.

UNIT III STATE UTILITY SERVICES 9

Distribution System, Commercial Operations of a Distribution Utility, Metering and Billing, Revenue Collection, Emerging Trends in Metering Technology, Available Transfer Capability losses and remedial measures.

UNIT IV TARIFF POLICY AND DETERMINATION OF TARIFF 9

Tariff policy, Tariff regulations, Tariff structure, fixed tariff, Availability Based Tariff (ABT), time of the day tariff, Multi Year Tariff, Assessment of tariff levels, Determination of tariff for Generation, transmission and distribution levels, Comparison of year wise tariff/ state wise. **Case Study**: Present tariff Scenario in Tamil Nādu and compare with other states.

UNIT V POWER PURCHASE MANAGEMENT 9

Scope of the Power Purchase Management, Definition and interpretation of terms of a model Power Purchase Agreement (PPA), Desirable Principles of Power Purchase Agreements, Requirements of PPA, Risks and responsibilities in a PPA, Negotiating Power Purchase Agreements, PPA - Financial and legal issues, Drafting of a model PPA.

Case Study: Study and Analysis of a sample PPA between a Generation and Distribution Utility, Financial Statement Analysis of a State Power Sector Organization, Power Project Appraisal, Returns of a large Power Project, etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Acquire knowledge about power scenario in India.
CO2: Understand the electricity acts and regulatory commission policies.
CO3: Identify elements in distribution utility and the concept of billing.
CO4: Evaluate the tariff policy and its regulations.
CO5: Understand and create awareness about power purchase and its management.

Attested

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REFERENCES:

1. Turan Goneu, “Electric Power Distribution System Engineering”, Third Edition, McGraw Hill, 2014.
2. Leon K. Kirchmayer, “Economic Operation of Power Systems”, First Edition, Wiley, 2009.
3. Herry Sarkar and Gopal K. Kadekod, “Energy Pricing in India: Perspective, Issues and Options”,First Edition, Intl Labour Organisation, 1988.
4. Dr.Manish Yadav, “Energy Laws (Regulation in Electricity Sector and Protection of Consumer Rights: A Critical Analysis)”, First Edition, Kamal Publishers, 2016.
5. Shrama K V, venkataseshaiah.P, “Energy Management and Conservation”, First Edition, I.K. International Publishing, 2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	1	-	2	1
CO2	1	3	1	-	2	1
CO3	1	3	1	-	2	1
CO4	1	3	1	-	2	1
CO5	1	3	1	-	2	1
Average	**1**	**3**	**1**	**-**	**2**	**1**

PW3151 ELECTRIC VEHICLE CHARGING INFRASTRUCTURE **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to EV Systems: Benefits of EV – Battery Charging Modes - Electric Vehicle Supply Equipment (EVSE) and its components – Classification of chargers based on charging levels : AC Slow Charger, DC Fast Charger - AC-DC Converter and DC-DC Converter for EV Charger: Types and Working Principles - Modes of charging based on IEC 61851 - Plugs and connectors - Cables: without thermal management, with thermal management - Standards related to Connectors and Communication – Challenges in Charging Infrastructure - Battery Swapping

UNIT II BUSINESS MODEL AND ELECTRICITY TARIFF STRUCTURE 9

Introduction - integrated business model - independent business model - tariff structure

UNIT III ELECTRIC DISTRIBUTION SYSTEM FOR FAST CHARGING INFRASTRUCTURE 9

Single line diagram of fast charging infrastructure - Major components of fast charging infrastructure - Single point of failure - Configuration of electric distribution considering redundancy - Other configurations

UNIT IV POWER QUALITY AND EMI/EMC CONSIDERATIONS 9

Power Quality: Impact of poor power quality from Power grid on EVSE - Impact of poor power quality from EVSE on power grid – EMI/EMC: Sources of EMI, Differential Mode Noise, Common Mode Noise, LISN, Measuring of EMI/EMC Spectrum, Design of DM filters, CM filters

UNIT V ENERGY STORAGE SYSTEMS 9

Need for Energy Storage Systems for charging infrastructure - Renewable Energy Resources and ESS for Fast Charging Infrastructure - Modes of operation - Microgrids for Charging Infrastructure

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Design and select AC and DC chargers.
CO2: Understand and create awareness about power purchase and its tariff policy and its regulations.
CO3: Design a fast-charging infrastructure in a distribution network.
CO4: Understand the consequences of power quality issues and EMI/EMC in power grid.
CO5: Analyze the need for ESS in EVSE and ESS integrated to the microgrid.

REFERENCES:

1. Sivaraman P, Sharmeela C, Sanjeevikumar P, "Fast Charging Infrastructure for Electric and Hybrid Electric Vehicles", First Edition, Wiley, 2023.
2. Sulab sachan, Sanjeevikumar P, Sanchari Deb, "Smart Charging Solutions for Electric and Hybrid Vehicles", First Edition, Scrivener Publishing LLC, 2022.
3. Iqbal Husain, "Electric and Hybrid Vehicles", Third Edition, CRC press, 2021.
4. L.Ashok Kumar, S.Albert Alexander, "Power converters for Electric Vehicles", First edition, CRC Press,2021.
5. Mehrdad Ehsani, Yimin Gao, Stefano Longo. Kambiz Ebrahimi," Modern Electric, Hybrid Electric, and Fuel cell vehicles", Third Edition, CRC Press,2019.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	-	2	3
CO2	3	1	1	-	2	3
CO3	3	1	1	-	2	3
CO4	3	1	1	-	2	3
CO5	3	1	1	-	2	3
Average	**3**	**1**	**1**	**-**	**2**	**3**

PW3111 **POWER ENGINEERING LABORATORY** **L T P C**
0 0 4 2

LIST OF EXPERIMENTS:

1. Power flow analysis by Newton Raphson method
2. Power flow analysis by Fast decoupled method
3. Distribution Load Flow Analysis: Ladder Iterative Technique
4. Contingency analysis: Generator shift factors and line outage distribution factors
5. State Estimation by Weighted Least Square Method
6. Digital Overcurrent Relay Setting and Relay Coordination
7. Voltage stability: PV and VQ curves
8. Characteristics of Solar PV System
9. Power Quality Analysis of Sinusoidal PWM Inverter
10. Maximum Power Point Tracking for Solar PV System

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Analyze the power flow using Newton-Raphson method, Fast decoupled method and Ladder Iterative Technique.
CO2: Perform contingency analysis and state estimation
CO3: Select and coordinate over current relay
CO4: Acquire knowledge in steady state voltage stability.
CO5: Analyze the characteristics of PV system, Wind Energy Conversion System and hybrid power system.

REFERENCES:

1. J. J. Grainger, W. D. Stevenson, “Power System Analysis”, First Edition, McGraw-Hill, 1994
2. Chetan Singh Solanki, “Solar Photovoltaic Technology and Systems” – A Manual for Technicians, Trainees and Engineers, PHI, 2014.
3. T. V. Cutsem, C. Vournas, ‘Voltage Stability of Electric Power Systems’, First Edition, Springer, 1998
4. A. J. Wood, B. F. Wollenberg, G. B. Sheblé, “Power Generation Operation and Control”, Third Edition, John Wiley and sons, 2013.
5. D P Kothari, I J Nagrath, R K Saket, “Modern Power System Analysis”, McGraw-Hill, Fifth Edition, 2022.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	3	2	-
CO2	2	1	2	3	2	-
CO3	2	1	2	3	2	-
CO4	2	1	2	3	2	-
CO5	2	1	2	3	2	-
Average	**2**	**1**	**2**	**3**	**2**	**-**

PW3112 ELECTRIC VEHICLE LABORATORY

L	T	P	C
0	0	4	2

LIST OF EXPERIMENTS:

1. Study of Grid to Vehicle (G2V) charging and Vehicle to Grid (V2G) charging.
2. Study of various charging levels practiced in EV charging infrastructure.
3. Performance Analysis of Uni-directional and Bi-directional converters used in EV charging.
4. Performance Analysis of slow and fast EV chargers.
5. Performance Analysis of wireless charging for Electric Vehicle.
6. Performance Analysis of various Battery Technologies.
7. Implementation of Smart Battery Management System (SBMS).
8. Study of Power Quality and impact of EV integration into the Electrical Distribution Network.
9. Design of Solar Powered Electric Vehicle Charging infrastructure.
10. Performance Analysis of E-Bicycle.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: acquire knowledge about various charging levels, G2V and V2G charging.

CO2: analyze about the performance of wired and wireless charging for EV.

CO3: model and analyze different rectifier circuits using computational software and to understand their various operating modes.

CO4: analyze the various power quality issues in the distribution network due to increasing penetration of EV charging infrastructure.

CO5: design and analyze the solar powered EVSE and determination of efficiency for e-bicycle.

REFERENCES:

1. Ned Mohan, T.M.Undeland, W.P Robbin, "Power Electronics: converters, Application and design", Third Edition, Wiley, 2007.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Fourth Edition, Pearson Education, 2013.
3. Iqbal Husain, "Electric and Hybrid Vehicles", Third Edition, CRC press, 2021.
4. L.Ashok Kumar, S.Albert Alexander, "Power converters for Electric Vehicles", First edition, CRC Press,2021.
5. Mehrdad Ehsani, Yimin Gao, Stefano Longo. Kambiz Ebrahimi," Modern Electric, Hybrid Electric, and Fuel cell vehicles", Third Edition, CRC Press,2019.
6. Sivaraman P, Sharmeela C, Sanjeevikumar P, "Fast Charging Infrastructure for Electric and Hybrid Electric Vehicles", First Edition, Wiley, 2023.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	2	-
CO2	3	2	1	3	2	-
CO3	3	2	1	3	2	-
CO4	3	2	1	3	2	-
CO5	3	3	1	3	2	-
Average	**3**	**2**	**1**	**3**	**2**	**-**

PW3201 ENERGY MANAGEMENT AND AUDIT **L T P C**
3 0 0 3

UNIT I GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT 9

Commercial and Non-commercial energy - Final Energy Consumption - Energy needs of growing economy - Energy Pricing - Energy Conservation and its importance – Energy Conservation versus Energy Efficiency- Energy Conservation Act 2001, Electricity Act 2003, Energy Conservation (Amendment) Act, 2010 and its features - Electricity Tariff – Schemes of Bureau of Energy Efficiency (BEE) - Need and Types of Energy Audit - Energy audit approach - understanding energy costs - maximizing system efficiencies - optimizing the input energy requirements – Instruments and metering for energy audit - Case study

UNIT II MATERIAL AND ENERGY BALANCE 9

Components of materials and energy balance – Basic principles - material and energy balance diagram - Energy policy and planning - roles and responsibilities of energy manager – employees training and planning- Financial Management: financial analysis technique - Simple Payback Period, Return on Investment, Net Present Value, Internal Rate of Return

UNIT III ENERGY EFFICIENCY IN THERMAL UTILITIES 9

Thermal energy basics - Introduction to fuels - properties of fuel oil, coal and gas - principles of combustion - combustion of oil, coal and gas - Boilers: Types and classification - performance and evaluation - energy conservation opportunities in boilers - Compressed Air System: Types of air compressors - Efficient Compressor Operation - Compressed air system components - Refrigeration System: Vapour Compression Refrigeration- Absorption Refrigeration – Common Refrigerants and Properties – Heat Pumps and their applications – Ventilation Systems - Standards and Labelling of Room Air Conditioners – Energy Savings Opportunities - Cogeneration: Need – Principle - Classification - Case Study

UNIT IV ENERGY EFFICIENCY IN ELECTRICAL UTILITIES 9

Electrical Load Management and Maximum Demand Control - Power Factor Improvement and its benefit - selection and location of capacitors - Automatic Power Factor Controllers - Electric motors: Types - losses in induction motor - motor efficiency - factors affecting motor performance - rewinding and motor replacement issues - energy saving opportunities with energy efficient motors - soft starters with energy saver – Fans: Types – Performance Evaluation - Efficient System Operation – Energy saving opportunities – Pumps :Types – Efficient Pumping system operation- Lighting System: Light source, choice of lighting, luminance requirements - Energy Efficient Lighting Controls - Energy Saving Opportunities - Case Study

UNIT V BUILDING MANAGEMENT SYSTEM AND ECBC ON ELECTRICAL POWER 9

Introduction - Energy Conservation Building Code (ECBC) – Building definition as in Energy Conservation (amendment) Bill 2010 – ECBC Guidelines for Electrical power – Lighting - Building water pumping system, Uninterruptible Power Supply – Escalators and Elevators, Building Energy Management System (BEMS) – Star rating of buildings – Energy Performance Index (EPI) – Energy Efficiency Measures – Case study

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Acquire basic knowledge in the field of energy management and auditing process.
CO2: Learn the basic concepts of economic analysis and load management.
CO3: Design effective thermal utility system.
CO4: Improve the efficiency in Electrical Utilities such as Lighting System, Motor, Fans and Pumps.
CO5: Acquire the fundamental concepts in the Building Energy Management System (BEMS), ECBC Code and Guidelines for Electrical power

REFERENCES:

1. Moncef Krarti, “Energy Audit of Building Systems: An Engineering Approach”, Third Edition, CRC Press, 2020
2. Sonal Desai, “Handbook of Energy Audit”, First Edition, McGraw Hill (India), 2015
3. Michael P. Deru, Jim Kelsey, “Procedures for Commercial Building Energy Audits”, Second Edition, American Society of Heating, Refrigerating and Air-conditioning Engineers, 2011
4. T.D. Eastop, D.R. Croft, “Energy Efficiency for Engineers and Technologists”, First Edition, Longman Scientific and Technical, 1990
5. Daniel Martinez, Ben W. Ebenhack, Travis Wagner, “Energy Efficiency Concepts and Calculations”, First Edition, Elsevier Science, 2019
6. “Energy Efficiency in Electrical Utilities”, Third Edition, Bureau of Energy Efficiency (BEE), India, 2010

7. Al Thumann, William J.Younger, Terry Niehus, “Handbook of Energy Audits”, 8th Edition, The Fairmont Press, Inc., 2010
8. Mehmet Kanoglu, Yunus A.Cengel,”Energy Efficiency and Management for Engineers, 1st Edition, Mc-Graw-Hill Education, 2020

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	-	3	2
CO2	2	1	2	-	3	2
CO3	2	1	2	-	3	2
CO4	2	1	2	-	3	2
CO5	2	1	2	-	3	2
Average	**2**	**1**	**2**	**-**	**3**	**2**

BA3251 OPERATIONS MANAGEMENT L T P C
3 1 0 4

OBJECTIVE:

- To provide an introduction to the field of operations management and explain the concepts, strategies, tools, and techniques for managing the transformation process that can lead to competitive advantage.

UNIT I INTRODUCTION 12

Operations Management- Nature, Scope, Historical Development, Functions- Long term Vs Short term issues- A Systems Perspective- Challenges- Manufacturing Trends in India-Operations Strategy – Strategic fit, framework - Production Design and Process Planning- Types of Production Processes-Plant Capacity-Capacity Planning- Make or Buy Decisions

UNIT II FACILITY DESIGN 12

Plant Location- Factors to be considered in Plant Location- Location Analysis Techniques- Choice of General Region, Particular community and Site- Multiple Plant Location Decision- Plant Location Trends. Layout of Manufacturing Facilities: Principles of a Good Layout- Layout Factors- Basic Types of Layout- Planning tools and techniques. Principles of Materials Handling- Materials Handling Equipment - Role of Ergonomics in Job Design.

UNIT III DESIGN OF WORK SYSTEMS 12

Product Design - Criteria, Approaches. Product development process. Process design and analysis - Work Study-Objectives- Procedure- Method Study and Motion Study- Work Measurement-Time Study-Performance Rating- Allowance Factors- Standard Time- Work Sampling Techniques- Job Sequencing and Scheduling.

UNIT IV PLANNING AND INVENTORY CONTROL 12

Operations planning – Aggregate Planning- Master Production Schedule, Material Requirements Planning. Basic Inventory Models- Economic Order Quantity- Economic Batch Quantity- Reorder Point-Safety Stock- Inventory Costs-Classification and Codification of Stock- ABC Classification-Materials. Supply Chain Management.

UNIT V QUALITY MANAGEMENT 12

Definitions of quality-The Quality revolution-Quality gurus; TQM philosophies - Quality Management tools, certification and awards- Quality Control: Acceptance Sampling- The Operating Characteristic Curve- Control Charts for Variables and Attributes; Quality Circles Lean Management – philosophy-continuous improvement -Six sigma.

TOTAL: 60 PERIODS

OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Understand the concepts of production and its design, capacity planning and make or buy decisions and apply and adapt the concepts in managing operations.

CO2: Understand and apply location models to complex plant location decisions and choose among the different types of layout by applying layout planning tools.

CO3: Understand the different approaches, analyze, design and develop the work system.

CO4: Understand, apply and evaluate the various inventory models and choose the best inventory control policy.

CO5: Understand the quality management principles, apply the quality tools and develop a quality management system.

READING LIST:

1. International Journal of Operations & Production Management – Emerald Insight
2. Journal of Operations Management – Wiley Online Library

REFERENCES:

1. Richard B. Chase, Ravi Shankar, F. Robert Jacobs, Operations and Supply Chain Management, McGraw Hill Education, 15th Edition (SIE), 2018.
2. Aswathappa K and Shridhara Bhat K, Production and Operations Management, 2nd Edition, Himalaya Publishing House, 2021.
3. Mahadevan B, Operations Management Theory and Practice, 3rd Edition, Pearson Education, 2015.
4. Russel and Taylor, Operations and Supply Chain Management, 8th Edition, Wiley, 2021.
5. William J Stevenson, Operations Management, 14th Edition, McGraw Hill, 2021.
6. Prof. K C Jain, Production and Operations Management, 1st Edition, Wiley, 2022.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	-	1	1	3	2	-
CO2	3	3	2	1	2	3	2	-
CO3	3	3	-	1	2	3	2	2
CO4	3	3	-	1	1	3	2	-
CO5	2	3	1	1	2	3	2	3
Average	**2.8**	**3**	**1.5**	**1**	**1.6**	**3**	**2**	**2.5**

PW3252 OPTIMIZATION TECHNIQUES FOR ENERGY MANAGEMENT **LT P C 3 0 0 3**

UNIT I PROBABILITY THEORY 9

The nature of random variables: populations and samples, parameters and statistics - Probability concepts: properties of random variables, probability distribution functions.

UNIT II DEMAND ANALYSIS AND FORECASTING 9

Drivers of energy demand - Sectoral energy demand: domestic, commercial, industrial, agriculture - Projections for future demands – Guidelines for Medium and Long-Term Power Demand Forecast – Time-Series and Machine Learning Methods.

UNIT III INTRODUCTION TO OPTIMIZATION 9

Problem formulation: decision variables, objective function, maxima and minima constraints - Analysis techniques: simulation, optimization and stochastic optimization - Multi-objective optimization - non-inferior solutions, trade off analysis, weighted and constraints method.

UNIT IV LINEAR PROGRAMMING AND APPLICATION 9

Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis -Power system planning using optimization techniques - case study.

UNIT V DYNAMIC PROGRAMMING AND APPLICATION 9

Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming - Optimal energy resource, technology mix in micro and macro level energy planning exercises - Power generation expansion planning - case study.

TOTAL: 45 PERIODS

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COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Define and use optimization techniques and concepts.
CO2: Understand the concept of optimization methods for energy system planning
CO3: Define an optimization problem and exploring the solution by applying optimization methods and interpreting results.
CO4: Excel the selection of optimization techniques for real time problems and to analyze the solutions.
CO5: Analyze the various operating modes of different configurations in different applications.

REFERENCES:

1. Taha, H. A.,"Operations Research—an Introduction", Tenth Edition, Pearson Education, 2019.
2. Vohra, N. D.,"Quantitative Techniques in Management", Fifth Edition, Tata McGraw-Hill Education, 2017.
3. Rardin, R. L.,"Optimization in operations research: Upper Saddle River", Second Edition, Pearson, 2017.
4. Dhillon, J. S., and Kothari, D. P,"Power system optimization", Second Edition, PHI Learning Private Limited, 2010.
5. Ayyub B.M., McCuen R.H., "Probability, Statistics and Reliability for Engineers and Scientists", Third Edition, CRC Press, 2011.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	2	2	1
CO2	3	1	1	2	2	1
CO3	3	1	1	2	2	1
CO4	3	1	1	2	2	1
CO5	3	1	1	2	2	1
Average	**3**	**1**	**1**	**2**	**2**	**1**

PW3251 **ENERGY STORAGE SYSTEMS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Necessity for Energy Storage – Types of Energy Storage – Comparison of Energy Storage Technologies – Applications

UNIT II MECHANICAL ENERGY STORAGE SYSTEM 9

Overview - Pumped Hydroelectric Storage (PHS) – Compressed-Air Energy Storage (CAES) – Various CAES – Flywheel Energy Storage (FES) – Comparison of PHS, CAES and FES

UNIT III ELECTROCHEMICAL ENERGY STORAGE 9

Fundamental concept of Batteries – measuring the battery performance, charging and Discharging of a battery, Power Density - Energy Density – C-Rate – Spider Diagram of Battery- Battery Energy Storage Systems (BESS) – Lead Acid Battery - Nickel – Cadmium Batteries - Lithium-ion Batteries – High Temperature Batteries – Metal – Air Batteries - Flow Batteries

UNIT IV FUEL CELL 9

History of Fuel Cell – Construction - Working Principle of Fuel Cell – Types – Hydrogen Fuel cells, Proton Exchange Membrane Fuel Cell, Solid Oxide Fuel Cell – Advantages and Disadvantages

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 9

Super capacitors, Principle – Applications, Superconducting Magnetic Energy Storage - Concept of Hybrid Storage – Applications, - Hydrogen Production - Hydrogen Storage Technologies - Safety and Management of Hydrogen Storage – Power to Gas Technology (P2G)

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Gained knowledge of various storage technologies
CO2: Understand the mechanical storage system
CO3: Do performance analysis of Various Battery Energy Storage System
CO4: Analyze the operation of fuel cell
CO5: Gain Knowledge on various types of alternate storage technologies and perform the selection based on techno-economic viewpoint.

REFERENCES:

1. David Linden, Thomas B.Reddy, “Handbook of Batteries”, Third Edition, Tata Mc-Graw Hill, 2002.
2. James Larminie, Andrew Dicks, “Fuel cell Systems Explained”, Third Edition, Wiley, 2018.
3. Ru-Shi Liu, Lei Zhang and Xueliang Sun, “Electrochemical Technologies for Energy Storage and Conversion”, First Edition, Wiley, 2012.
4. P.Jayarama Reddy, “Principles of Energy Storage Systems”, BS Publications, Hyderabad, First Edition, 2022.
5. G.D.Rai, “Non-Conventional Energy Sources”, VI Edition Khanna Publishes, First Edition, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	1	2
CO2	2	1	3	-	1	2
CO3	2	1	3	-	1	2
CO4	2	1	3	-	1	2
CO5	2	1	3	-	1	2
Average	**2**	**1**	**3**	**-**	**1**	**2**

PW3211 ENERGY AUDIT LABORATORY

L T P C
0 0 4 2

LIST OF EXPERIMENTS:

1. Study of Energy Conservation and Energy Audit Using Energy Audit Instruments.
2. Performance Analysis of Electric Motor and Energy Efficient Motor (EEM).
3. Determination of harmonics, voltage sag, voltage swell and THD using Power Quality Analyzer.
4. Power Factor Improvement and Power Quality Enhancement in Distribution System using PSCAD software.
5. Design of Passive Filter and Harmonic Load Flow Analysis using ETAP software.
6. Lighting design using DIALUX to determine the lux level and efficacy for different lighting fixtures.
7. Powel Loss Estimation of a distribution system using DIGSILENT Power Factory.
8. Performance Assessment of Pumps and Fans.
9. Study of Cogeneration.
10. Design of grid connected Solar PV using PVSyst.
11. Performance analysis of Compressors and Blowers.
12. Performing Energy Audit for Commercial and Industrial building.

P = 60, TOTAL = 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Acquire knowledge in the field of the energy audit and performance analysis of EEM.
CO2: Analyze the various PQ issues and the mitigation measures in the Distribution System using PSCAD/ETAP software.
CO3: Perform cost benefit analysis for the Pumps and Fans.
CO4: Learn various waste minimization and resource conservation techniques for electrical system.
CO5: Design and Develop a grid connected SPV system using PVSyst.

REFERENCES:

1. Clive Beggs, “Energy: Management, Supply and Conservation Management, Supply and Conservation”, Second Edition, Routledge Taylor & Francis Group, 2009.
2. Albert Treemann & Paul Mehta, “Handbook of Energy Engineering”, Eighth Edition, River Publishers,2021.
3. W.R. Murphy & G. Mckay Butter worth, “Energy management”, First Edition, Elsevier publications. 2012.
4. Shrama K V, venkataseshaiah.P , “Energy Management and Conservation”, First Edition, I.K. International Publishing, 2013.
5. Arry C. White, Philip S. Schmidt, David R. Brown, ” Industrial Energy Management Systems”, First Edition, Publishing Corporation, New York, 1994.
6. Economic Analysis of Demand Side Programs and Projects – California Standard Practice Manual, June 2002.
7. “Energy Efficiency in Electrical Utilities”, Third Edition, Bureau of Energy Efficiency (BEE), India, 2010.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	-	1
CO2	2	1	3	3	-	1
CO3	2	1	3	3	-	1
CO4	2	1	3	3	-	1
CO5	2	1	3	3	-	1
Average	**2**	**1**	**3**	**3**	**-**	**1**

PW3001 **DISTRIBUTION SYSTEM AND AUTOMATION** **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Overview of Distribution System -Importance of Distribution Systems - Differences of Power Supply between Urban and Rural Areas - Distribution system Consumer Classification

UNIT II OVERVIEW OF DISTRIBUTION SYSTEM 9

Factors affecting planning - Planning Techniques - Planning Models (Short Term Planning, Long Term Planning and Dynamic Planning) - Planning for the future - Load forecasting -Load characteristics and Load models

UNIT III DISTRIBUTION SYSTEM DESIGN 9

Types of Sub-Transmission - Distribution Substation - Bus Schemes - Substation Location - Rating of Substation - Calculation of voltage drops with primary feeders and secondary feeders, uniformly distributed load and non-uniformly distributed load

UNIT IV POWER QUALITY AND DISTRIBUTION SYSTEM PERFORMANCE ANALYSIS 9

Power Quality Problems in Distribution Systems - Power Quality Study as per IEEE and IEC Standards - Distribution Feeder Analysis – Ladder Iterative Technique, Power loss calculations and control measures - Distribution system voltage regulation: voltage control - Application of capacitors in Distribution system - Case study on TNEB distribution system

UNIT V DISTRIBUTION AUTOMATION 9

Definitions - Distribution Automation (DA) Planning – Communication: Wireless and Wired Communications - DA Communication Protocols, Architectures and User Interface, Sensors, Supervisory Control and Data Acquisition Systems (SCADA) - Case Studies

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about distribution system management
CO2: Understand about distribution system operation and planning
CO3: Understand the design concept of a distribution system
CO4: Acquire knowledge about Power quality issues in distribution system
CO5: Gain ability to understand the distribution system automation

REFERENCES:

1. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007
2. Turan Gonen, "Electric Power Distribution System Engineering", McGraw Hill Company, 1986
3. "IEEE Recommended practice for Electric Power Distribution for Industrial Plants", IEEE Standard 141 – 1993.
4. Pansini, "Electrical Distribution Engineering", The Fairmont Press, Inc., 2007
5. G.T.Heydt, "Electric Power Quality", stars in a circle publication, 1991

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	2	-
CO2	3	1	2	1	2	-
CO3	3	1	2	1	2	-
CO4	3	1	2	1	2	-
CO5	3	1	2	1	2	-
Average	**3**	**1**	**2**	**1**	**2**	**-**

PW3002 HYBRID POWER AND ENERGY SYSTEMS **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO HYBRID POWER AND ENERGY SYSTEMS 9

Introduction - Importance of Hybrid Power Systems – Need for Hybrid Systems – Configurations: Solar – Battery, Solar – Wind – Battery, Solar-Wind-Fuel Cell-Diesel, Wind-Biomass-Diesel, Micro-Hydel-PV– Advantages and Disadvantages

UNIT II POWER ELECTRONIC CONVERTERS AND CONFIGURATIONS FOR HYBRID SYSTEMS 9

Introduction – Types: AC bus connected, DC bus connected – Converters: DC – DC converters, AC – DC converters, DC – AC converters, Multilevel converters, Three port converters

UNIT III STANDARDS FOR HYBRID SYSTEMS 9

IEEE 2800-2022: Inverter Based Resources (IBR), POC, POM, POI, RPA, IBR continuous rating, reactive power capability, voltage and reactive power control modes, Active power – frequency response, Low and high voltage ride through capability, Current injection during ride through, Power quality

UNIT IV HYBRID ENERGY STORAGE SYSTEMS 9

Overview of Energy Storage Systems – Types – Hybrid Energy Storage System Configurations, Control Strategies – Energy Storage System: Modes of Operation – Energy Storage System for Fast Charging Stations

UNIT V CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS 9

Hybrid Systems- Range and type of Hybrid systems – Performance Analysis – Cost Analysis – HOMER software - Case studies of Diesel-PV, Wind-PV-Fuel-cell, Biomass-Diesel-Fuel-cell systems- Hybrid micro grid system for rural electrification

TOTAL = 45 PERIODS

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COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.

CO2: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid systems.

CO3: Understand the IEEE Standard 2800-2022 and its technical requirements for IBR plant connected to associated transmission systems

CO4: Understand the various energy storage technologies, and its types, modes of operation, energy storage system for fast charging stations

CO5: Perform Case studies of hybrid systems, cost analysis, energy resources optimization using HOMER software

REFERENCES:

1. Ernst Joshua, "Wind Energy Technology", PHI, India, 3rd Edition, 2018.
2. Bahman Zohuri, "Hybrid Energy Systems", Springer, First Edition, 2018
3. Sanjeevikumar P, Sharmeela C, Sivaraman P, Jens Bo Holm-Nielsen, "Residential Microgrids and Rural Electrifications", 1st edition, Academic Press, 2021.
4. Gray, L. Johnson, "Wind Energy System", Prentice Hall of India, 2nd Edition, 2006.
5. B.H.Khan "Non-conventional Energy sources", Tata McGraw hill Publishing Company, New Delhi, 3rd Edition, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	2	1
CO2	3	1	2	-	2	1
CO3	3	1	2	-	2	1
CO4	3	1	2	-	2	1
CO5	3	1	2	-	2	1
Average	**3**	**1**	**2**	**-**	**2**	**1**

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PW3051 DESIGN AND MODELLING OF SOLAR PV SYSYTEMS LT P C
3 0 0 3

UNIT I SOLAR PV SYSTEMS OVERVIEW 9

Introduction to Solar PV systems – Solar PV modules and its types -Types of PV systems: Grid Connected and Standalone – Inverter and its types: string inverter, central inverter, micro inverter – Charge Controller - MPPT – I-V curve – P-V curve - tilt angle – azimuth angle – Standard Test Conditions (STC)

UNIT II GRID-CONNECTED PHOTOVOLTAIC SYSTEMS 9

Introduction – Types: Rooftop Solar PV systems, Ground Mounted Solar PV systems and Floating Solar PV systems – Single Line Diagram - Balance Of Plant (BOP) - String Sizing - Power and Energy Losses - Temperature and Shading Effects - Power Plant Controller (PPC) – Grounding: IEEE 2778-2020 – Levelized Cost Of Energy Analysis (LCOE) – Power Evacuation- Net Metering

UNIT III STANDALONE SOLAR PV SYSTEMS 9

Introduction—Design Methodology for Standalone SPV systems –- Need for Balance Of System (BOS) – Batteries for SPV system– Installation, Trouble Shooting and Safety

UNIT IV ENERGY ESTIMATION 9

Introduction - Energy estimation for Grid Connected PV systems using PVsyst – Energy Estimation for standalone PV systems using PVsyst – Energy losses: Array Incidence Losses, Incidence Angle Modifier (IAM), ohmic losses, Module Quality Loss, Module Mismatch Loss, Soiling Loss, Light Induced Degradation (LID), module degradation loss, connection loss, system availability loss, Potential-Induced Degradation (PID), inverter loss, inverter clipping loss – Performance Ratio (PR) – Capacity Utilization Factor (CUF)

UNIT V GRID CODE REQUIREMENTS AND STANDARDS 9

CEA Technical Standard for Connectivity to the Grid: Voltage, Frequency, LVRT, HVRT, Power Factor, Harmonics, DC Injection, Voltage Flicker – IEEE 2800- 2022: Q vs P and Q vs V, Reactive Power Capability, Power Quality, Protection, Low and High Voltage Ride Through – Low and High Frequency Ride Through

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1: Review the perspectives of solar PV systems and its types
CO2: Understand various types of Grid Connected Solar PV system and SPV plant grounding
CO3: Study the various aspects of standalone solar PV systems
CO4: Perform Energy estimation of grid connected and standalone solar PV system
CO5: Understand Technical requirements of grid codes and standards for interconnection

REFERENCES:

1. Suneel Deambi, “Photovoltaic System Design”, 1st edition, CRC press, 2016.
2. John Bailfour, Michael Shaw, Nicole Bremer Nash, “Introduction to Photovoltaic System Design”, 1st edition, Jones & Bartlett Learning, 2011.
3. Marco Rosa-Clot, Giuseppe Marco Tina, “Floating PV Plants”, 1st edition, Academic Press, 2020.
4. John Bailfour, Michael Shaw, Nicole Bremer Nash, “Advanced Photovoltaic System Design”,

1st edition, Jones & Bartlett Learning, 2011.
5. N.D. Kaushika, Anuradha Mishra, Anil K. Rai, “Solar Photovoltaics Technology, System Design, Reliability and viability”, 1st edition, Springer, 2018.
6. Sanjeevikumar P, Sharmeela C, Jens Bo Holm-Nielsen, Sivaraman P, “Power quality in modern power systems”, 1st edition, Academic Press, 2020.
7. Rabindra Kumar Satpathy, Venkateswarlu Pamuru, “Solar PV Power”, 1st edition, Academic Press, 2020.
8. Chetan Singh Solanki, “Solar Photovoltaic Technology and Systems” – A Manual for Technicians, Trainees and Engineers, PHI, 2014.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	1	-
CO2	3	1	2	2	1	-
CO3	3	1	2	2	1	-
CO4	3	1	2	2	1	-
CO5	3	1	2	2	1	-
Average	**3**	**1**	**2**	**2**	**1**	**-**

PW3003 SCADA SYSTEM AND APPLICATIONS MANAGEMENT **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO SCADA **9**

Overview- general features - SCADA architecture - SCADA Applications – Benefits - Remote Terminal Unit (RTU) - Human- Machine Interface Units (HMI) - Display Monitors/Data Logger Systems - Intelligent Electronic Devices (IED) - Communication Network - SCADA Server, SCADA Control systems and Control panels

UNIT II SCADA COMMUNICATION **9**

SCADA Communication requirements - Communication protocols: Past, Present and Future - Structure of Communications Protocol - Comparison of various communication protocols - IEC 61850 based communication architecture - Communication media like Fiber optic, PLCC- Interface provisions and communication extensions -synchronization with NCC, DCC, IOT, Cyber cell -Redundancy of Network

UNIT III SCADA IN POWER SYSTEM AUTOMATION **9**

Applications in Generation, Transmission and Distribution sector - Substation SCADA system- Functional description - System specification- System selection such as Substation configuration- ring configuration – Statistical Analysis System (SAS) Cubicle Concepts - Gateway Interoperability list - Signal Naming Concept- System Installation-Testing and Commissioning
CASE STUDIES: SCADA Design for 66/11kV and 132/66/11kV or 132/66 kV or any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations

UNIT IV ENERGY MANAGEMENT CENTRE 9

Functions-Control and Load Management - Economic Dispatch - Distributed Centre's and Power Pool Management-Energy Management System and its role

UNIT V SCADA MONITORING AND CONTROL 9

Online monitoring the event and alarm system: Trends and Reports, Blocking List - Event Disturbance Recording - Control Function: Station control, Bay Control, Breaker Control and Disconnector Control

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Learn the SCADA system components and its significance.

CO2: Understand the need and advantages of communication protocols for SCADA

CO3: Get implementation knowledge about the application of SCADA to Power System.

CO4: Get exposure to the best operating mechanism for Energy Centre based on SCADA concepts

CO5: Understand the need and importance of monitoring and control logic for SCADA based power systems.

REFERENCES:

1. Stuart A. Boyer, "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA, 2004
2. Gordon Clarke, Deon Reynders, "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK,2004
3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006
4. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003
5. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric Power", PennWell, 1999

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	1	2
CO2	3	1	2	-	1	2
CO3	3	1	2	-	1	2
CO4	3	1	2	-	1	2
CO5	3	1	2	-	1	2
Average	**3**	**1**	**2**	**-**	**1**	**2**

PW3054 GRID INTEGRATION OF RENEWABLE ENERGY SOURCES **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**

Introduction to Renewable Energy (RE) based grid integration - Concept of mini/micro/nano grids and Smart grids - Different types of grid interfaces - Issues related to grid integration of small and large scale of synchronous generator based - induction generator based and converter-based sources together - Influence of WECS on system transient response – Technical and Economic Aspects of Grid Integration of RES

UNIT II NETWORK INFLUENCE OF GENERATION TYPE **9**

Interconnection standards and grid code requirements for grid integration – starting – Network voltage management – Thermal/Active Power management – Network power quality management – Transient system performance – Fault level issues –Low Voltage Fault Ride Through (LVRT) – Protection – Study of Blackouts and Brownouts – Causes, effects and mitigation

UNIT III GRID INTEGRATION OF WIND POWER **9**

Introduction-Electric Grid- Embedded Generation- Functional Requirements of Wind Power Plant (WPP) in Electric Grid- Types of WPP and Wind Farm Grid Connections - Interface Issues - Operational Issues: Power System Stability, Frequency Control, Short Term Balancing, Long Term Balancing, Transmission and Distribution System Impacts, Economic Dispatch and Unit Commitment – Sitting WPPs for Effective Grid Integration - Grid Integration issues in India – Challenges for Grid Integration – Wind Power Integration Standards – Super Grid Strategy

UNIT IV GRID- CONNECTED SPV SYSTEM **9**

Introduction- Configurations-Components of Grid-connected SPV system– Grid-connected PV System Design: Small Power Applications and Power Plants–Safety in installation of SPV system– Installation and troubleshooting of SPV power plants - International PV programs

UNIT V GRID CODE COMPLIANCE AND GRID INTEGRATION STANDARDS **9**

IEC TS 63102-2021: Compliance assessment methods – Operating area – Control performance – Fault ride through – Power Quality – IEEE standards: IEEE 2800-2022, IEEE 1547-2018- CEA standards: technical standards for connectivity to grid, Distributed Energy Resources- RE Policies and Regulations in India

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1: Know about the integration of various renewable energy sources into the grid.
CO2: Analyze various grid issues due to renewable energy sources.
CO3: Analyze and understand the grid-connected WPP.
CO4: Design the grid connected SPV system.
CO5: Understand about the various grid interconnection standards and grid code compliance

REFERENCES:

1. Joshua Earnest, "Wind power technology", II Edition, PHI, 2015.
2. Brenden Fox, Damian Flynn and Leslie Bryans, "Wind Power Integration Connection and system operational aspects", The Institute of Engineering and Technology, London, United Kingdom, 2007.
3. Chetan Singh Solanki, "Solar Photovoltaic Technology and Systems" – A Manual for Technicians, Trainees and Engineers, PHI, 2014.
4. Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics", Earthscan, UK, 2007.
5. Heier, Siegfried, "Grid Integration of Wind Energy Conversion Systems", Germany, Wiley, 2006.
6. Joshua Earnest, Tore Wizelius, "Wind Power Plants and Project Development", Second Edition, PHI learning, 2017.
7. IEC TS 63102:2021 Grid code assessment methods for grid connection of wind and PV power plants
8. CEA technical standards for connectivity to the grid
9. CEA technical standards for connectivity of the distributed generation resources
10. IEEE Std 2800-2022 IEEE standard for interconnection and interoperability of inverter-based resources (IBRS) interconnecting with associated transmission electric power systems
11. IEEE Std 1547-2018 IEEE standard for interconnection and interoperability of distributed energy resources with associated electric power systems interface.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	2	-
CO2	3	1	2	1	2	-
CO3	3	1	2	1	2	-
CO4	3	1	2	1	2	-
CO5	3	1	2	1	2	-
Average	**3**	**1**	**2**	**1**	**2**	**-**

Attested

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PW3058 **WASTE TO ENERGY CONVERSION** **L T P C**
3 0 0 3

UNIT I WASTE SOURCES AND CHARACTERIZATION 9

Introduction - Principles of Waste Management and Waste Utilization, Waste Management Hierarchy - 3R Principle: Reduce, Reuse and Recycle – Waste Production in Domestic, Industrial and Agriculture Sectors - Classification of Waste: Agro based, Forest Residues, Domestic Waste, Industrial Waste (Hazardous and Non-Hazardous) – Characterization of Waste for Energy Utilization – Waste Selection Criteria

UNIT II TECHNOLOGIES FOR WASTE TO ENERGY CONVERSION 9

Biomass Resources and their Classification - Types of Biogas Plants – Biogas Plant Technology and Status - Biomass Conversion Technology: Combustion and Incineration, Biochemical Conversion (Energy Production through Anaerobic Digestion and Fermentation), Thermochemical Conversion (Combustion, Pyrolysis, Gasification, Liquefaction) – Waste to Energy Plasma Arc Gasification (PAG) Technology - Biomass Energy Programme in India

UNIT III BIOMASS GASIFIERS, PYROLYSIS AND BIOMASS HANDLING 9

Gasifiers: Fixed-Bed/Moving-Bed Gasifier – Updraft, Downdraft, Fluidized-Bed Gasifier – Plasma Gasification - Construction and Operation Pyrolysis – Types of Pyrolysis: Slow Pyrolysis, Fast Pyrolysis – Pyrolysis Product Types: Solid, Liquid and Gas Biomass Handling – Introduction – Design of a Biomass Energy System – Biomass-Handling System: Receiving – Storage and Screening-Feed Preparation-Conveying-Feeding

UNIT IV WASTE TO ENERGY OPTIONS AND ENVIRONMENTAL IMPLICATIONS 9

Landfill Gas, Collection and Recovery - Refuse Derived Fuel (RDF) - Solid Recovered Fuel (SRF) - Energy from Plastic Wastes: Non-Recyclable Plastic Wastes for Energy Recovery – Energy from Rubber Wastes - Benchmarking and Standardization of Energy Recovery from Waste – Environmental Standards for Waste to Energy Plant Operations – Carbon Credits: Carbon Foot Calculations and Carbon Credit Transfer Mechanism

UNIT V CENTRALIZED AND DECENTRALIZED WASTE TO ENERGY PLANTS 9

Waste Activities: collection, segregation, transportation and storage requirements - Location and Siting of Waste to Energy plants - Industry Specific Applications: Sugar, Pulp and Paper, Refinery and Petrochemical Industry - Centralized and Decentralized Energy Production for Municipal Solid Waste (MSW) - Comparison of Centralized and decentralized systems and its operations – Case Studies: Success and Failures of Indian Waste to Energy Plants

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1: Understand the various types of wastes from which energy can be generated and characterization of waste for energy utilization
CO2: Gain knowledge on the various technologies for waste to energy conversion
CO3: Develop knowledge on various types of biomass gasifiers and their operations, types of pyrolysis process and Biomass handling
CO4: Gain knowledge on waste to energy conversion options, environmental standards for waste to

energy plant operations and Carbon Credit Mechanism

CO5: Understand the principles of Centralized and Decentralized Waste to Energy Production plants through case studies.

REFERENCES:

1. Khandelwal, K. C. and Mahdi, S. S.," Biogas Technology - A Practical Hand Book - Vol. I & II", Tata McGraw Hill Publishing Co. Ltd., 1983
2. C. Y. WereKo-Brobby and E. B. Hagan," Biomass Conversion and Technology", John Wiley & Sons, 1996
3. Shobh Nath Singh, "Non-Conventional Energy Resources", Pearson India, 2015
4. Tchobanoglous, George, and Frank Kreith," Handbook of Solid Waste Management", 2nd Edition: McGraw-Hill, New York,2002
5. Paul Breeze," Energy from Waste (Power Generation)", First Edition, Academic Press, 2017
6. Banwari Lal and Pratwardhan," Wealth from Waste: Trends and Technologies", TERI Press
7. S.N.Mukhopadhyay, "Fundamentals of Waste and Environmental Engineering", TERI Press
8. "Industrial and Urban Waste Management in India", TERI Press
9. Report of the Task Force on Waste to Energy, Niti Ayog (Formerly Planning Commission), 2014, Source: www. swachhbharaturban.gov.in/Task Force Report on WTE
10. Prabir Basu, "Biomass Gasification and Pyrolysis- Practical Design", Academic Press,2010

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	2	3
CO2	3	1	2	-	2	3
CO3	3	1	2	-	2	3
CO4	3	1	2	-	2	3
CO5	3	1	2	-	2	3
Average	**3**	**1**	**2**	**-**	**2**	**3**

PW3055 IOT FOR SMART POWER SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Evolution of Internet of Things (IoT) –Definitions and Characteristics – Technologies for IoT– Sensors, Actuators and its types –Basics of Web Service and CLOUD Computing - Big data analytics - Importance of IoT in power systems - IoT standards

UNIT II IOT ARCHITECTURE AND PROTOCOLS 9

IoT Architecture – Layers – Protocol: SCADA, RFID – Internet of Energy (IoE) architecture and its requirements for Power Systems - IoT communication topologies for power system application

UNIT III IOT FOR SMART GRID 9

Integration of Internet of Things (IoT) into Smart Grid (SG) – Smart Grid Architectures: Four layered

IoT, Web-enabled SG Architecture - Big Data and Cloud for IoT aided SG system- Sensors for Smart Power Grids: Smart Metering and Grid Configuration- Synchronization of Current and Voltage Transducers - Phasor Measurement Units (PMU) - Sending Sensor data over the internet - Cyber Security for Smart Grid

UNIT IV IOT BASED SMART MONITORING SYSTEMS 9

Infrastructure for Smart Metering – Energy Efficiency in Residential, Commercial Buildings – Smart Power Quality Monitoring – Transformer Monitoring System - Smart Monitoring for EV Charging Infrastructure-Case studies

UNIT V IOT FOR ENERGY MANAGEMENT 9

Smart Energy Management – Cyber Physical Systems – Smart Electricity Management – Demand Side Management-Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about various IoT technologies and its importance in power system
CO2: Able to analyze different IoT architectures and communication topologies for power system applications
CO3: Understand IoT for Smart Grid
CO4: Attain knowledge about various IoT based smart monitoring systems
CO5: Apply IoT for Energy Management

REFERENCES:

1. Raj Kamal, “Internet of Things Architecture and Design Principles”, McGraw Hill Education (India) Private Limited, Second Edition, 2022.
2. Kostas Siozios, Dimitrios Anagnostos, Dimitrios Soudris, “IoT for Smart Grids: Design Challenges and Paradigms”, First Edition, Springer, 2019.
3. Pawan Kumar, Srete Nikolovski, Z Y Dong, “Internet of Energy Handbook”, 1st Edition, CRC Press, 2021.
4. Sharmeela C, Sanjeevikumar P, Sivaraman P, Meera Joseph, “IoT, Machine Learning and Blockchain Technologies for Renewable Energy and Modern Hybrid Power Systems”, First Edition, River Publishers, 2023.
5. Vahid Vahidinasab, Behnam Mohammadi-Ivatloo, “Electric Vehicle Integration via Smart Charging Technology, Standards, Implementation, and Applications”, First Edition, Springer, 2022.
6. Mohammadreza, Behnam, Kazem Zare, Amjad, "IoT Enabled Multi-Energy Systems", First Edition, Academic Press, 2023
7. O.V.Gnana Swathika, K.Karthikeyan, P.Sanjeevikumar,”IoT Analytics and Renewable Energy Systems - Vol. 1 and Vol.2”, First Edition, CRC Press, 2023

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	-	2	1
CO2	3	1	2	-	2	1
CO3	3	1	2	-	2	1
CO4	3	1	2	-	2	1
CO5	3	1	2	-	2	1
Average	**3**	**1**	**2**	**-**	**2**	**1**

PW3057 RENEWABLE ENERGY TECHNOLOGY LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Renewable Energy Sources Vs Non-Renewable Energy Sources - Global Renewable Energy (RE) Availability - RE Resources available in India: Current Generation and utilization of RE Resources in India - Potential of Renewable Energy in Power Production and Need for Renewable Energy Technology – Non-Conventional Energy (NCE) for Rural India – NCE and Cost.

UNIT II SOLAR ENERGY 9

Solar Radiation and its measurements - Solar Thermal Energy Conversion from Solar Plate Collectors and Concentrating Collectors (CC) – CC : Types – Classification –Applications of Solar Thermal Energy: Solar Water Heating system - Direct Solar Electricity Conversion from Photovoltaics - Types of Solar Cells – Solar Photovoltaic (SPV) Systems: On-grid and Off-grid SPV System - Applications: Domestic Lighting, Solar Street Lighting, Rural Irrigation, Solar Powered Refrigerator - Building Integrated Photovoltaic (BIPV) – Building Adaptive Photovoltaic (BAPV)

UNIT III WIND ENERGY 9

Basic Principle of Wind Generation – Wind Data and Analysis - Principle of Wind Power Generation - Wind Site and its Resource Assessment - Wind Mills and Sub-Systems – Classification of Wind Turbines – Operating Characteristics of Wind-Mill – Wind Turbine Controls for Wind Power Plants (WPPs) : Stand-alone Mode – Grid Connected Wind Turbine Generator (GWTG) - Hybrid Systems – WPP Control Overview - Wind Power Plant (WPP) Control Strategies: FGS-FP, FGS-VP,VGS-FP and VGS-VP - Classification of Wind Power Plants (WPPs): Type-A WPP, Type-B WPP, Type-C WPP and Type-D WPP – Environmental Impact of Wind Energy

Attested

UNIT IV BIOENERGY 9

Biomass Resources - Biomass Conversion Technologies and their classification, Biogas Generation:

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Principle - Different Biogas Digesters: Floating Drum Type and Fixed Dome Type – Power Generation Systems using Biofuels: Power Generation from Biogas and Power Generation using Liquid Waste – Biomass Cogeneration Systems

UNIT V OTHER TYPES OF ENERGY 9

Energy Conversion from Hydrogen and Fuel cells, Introduction to Geothermal Energy - Mining of Geothermal Heat – Geothermal Field – Geothermal Resources – Environmental Impact from extracting Geothermal Energy - Geothermal potential in India – Ocean Thermal Energy Conversion Systems (OTEC): Historical Review – Principle - Different OTEC Systems – Details of OTEC Plant Components – Location and Environmental Impact of OTEC plants - Tidal Energy: Introduction – Working of the Tidal Plant -Layout of a typical Tidal Power House – Major problem associated with Tidal Plants – Wave Energy : Introduction – Wave and Wave Generation – Ocean Wave Parameters – Wave Energy Conversion Devices – Environmental Effects of Wave Energy

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Gain knowledge about the Renewable Energy (RE) Resource potential available in India as well as global RE scenario and need for RE Technology.

CO2: Understand the basics of Solar radiation, Solar Thermal Energy Conversion and SPV systems.

CO3: Understand the concepts of various Wind Energy Conversion System.

CO4: Gain knowledge about Bioenergy and Biomass Conversion Technologies.

CO5: Gain knowledge about energy conversion technologies for harnessing the energy from other RE resources such as Hydrogen, Fuel Cell, Geothermal, OTEC, Wave Energy and Tidal Energy.

REFERENCES:

1. Twidell and Wier,” Renewable Energy Resources”, CRC Press, 2010.
2. Tiwari and Ghosal,” Renewable Energy Resources”, Narosa Publishing India, 2015.
3. B.H.Khan, ”Non – Conventional Energy Resources”, Tata Mc Graw Hill, 2006.
4. V.M.Domkundwar, A.V.Domkundwar, “Solar Energy and Non-Conventional Energy Sources”, Dhanpat Rai & Co. Pvt. Ltd., India, 2018.
5. D.P.Kothari, K.C.Singhal, ”Renewable Energy Sources and Emerging Technologies”, Prentice Hall, India, 2015.
6. D.S.Chauhan, S.K. Srivastava, “Non – Conventional Energy Resources”, New Age Publishers, 2006.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	1	3
CO2	2	1	3	-	1	3
CO3	2	1	3	-	1	3
CO4	2	1	3	-	1	3
CO5	2	1	3	-	1	3
Average	**2**	**1**	**3**	**-**	**1**	**3**

Attested

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PW3053 **ENERGY EFFICIENT BUILDINGS** **LT P C**
3 0 0 3

UNIT I CLIMATE AND SHELTER 9

Historic buildings – Modern architecture – Examples from different climate zones –Thermal comfort – Solar geometry and shading – Energy modeling techniques– Integrative Modeling methods and building simulation.

UNIT II PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN 9

Energy conservation in buildings – Day lighting – Solar based Water heating - Advances in thermal insulation – Heat gain/loss through building components - Solar architecture.

UNIT III PASSIVE SOLAR HEATING 9

Basics of Passive solar – Mechanical Systems – South Facing Glass – Thermal mass – Orientation – site planning for solar access - Direct gain – thermal storage wall – Sunspace –Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Design guidelines and natural cooling guidelines.

UNIT IV ENERGY CONSERVATION IN BUILDING 9

Air conditioning – HVAC equipment's – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles – ECBC applicability – Building Envelope – Comfort system and controls – Lighting – Electrical Power and Renewable Energy.

UNIT V EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9

Maximum Demand Controller, Automatic Power Factor Controller, Energy Efficient Motor – Energy Efficient Lighting System and Energy Efficient Transformers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Understand the different climate zones and modelling methods.
CO2: Design energy conscious building.
CO3: Understand the concepts of Passive Solar Heating (PSH) and design guidelines for PSH.
CO4: Gain knowledge about the energy conservation techniques in buildings.
CO5: Know about different energy efficient technologies for electrical system.

REFERENCES:

1. Joseph Clarke, "Energy Simulation in Building Design", II Edition, Butterworth, 2001
2. J. K. Nayak and J. A. Prajapati, "Handbook on Energy Conscious Buildings", Solar Energy Centre, MNES, May 2006
3. "Energy Conservation Building Codes Guide Book", 2017

4. “Passive Solar Building - Design Strategies”, Guidelines for Home Passive Solar Industries Council, National Renewable Energy Laboratory, USA, 2001
5. J. Douglas Batcomb, “Passive Solar Building”, The MIT Press, 1992
6. Thomas H.Kuehn, James W. Ramsey and J. L. Threlkeld, “Thermal Environmental Engineering”, 3rd Edition, Prentice Hall, 1970
7. Zhiqiang John Zhai, “Energy Efficient Buildings: Fundamentals of Building Science and Thermal Systems”, 1st Edition, Wiley, 2022
8. David S-K. Ting, Rupp Carriveau, “Energy Generation and Efficiency Technologies for Green Residential Buildings (Energy Engineering)”,IET, 2019

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	2	-	3
CO2	2	1	3	2	-	3
CO3	2	1	3	2	-	3
CO4	2	1	3	2	-	3
CO5	2	1	3	2	-	3
Average	**2**	**1**	**3**	**2**	**-**	**3**

PW3056 MICRO GRID OPERATION AND CONTROL **LT P C**
3 0 0 3

UNIT I MICRO SOURCES AND STORAGE **9**

Microgrid Structure and Operating Modes – Solar PV – Wind Energy – Fuel Cell –Battery – Super capacitor

UNIT II DC MICROGRID **9**

Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

UNIT III AC MICROGRID **9**

Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

Attested

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UNIT IV HYBRID MICROGRID 9

Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled –Control Strategies: Different modes of operation during transition – Simulation Studies

UNIT V MICROGRID PROTECTION 9

Protection: Effect on Relay Protection of distribution network, Differential Relay Protection, Directional Impedance Relay Protection– Islanding: Active and Passive Techniques– Earthing: Requirements, Earthing mode of DG in TN/TT Earthing System, Earthing mode of DG in IT

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Analyze micro-sources and storage systems.
CO2: Analyze the configurations and control aspects of AC microgrid.
CO3: Understand and analyze the configurations and control aspects of DC microgrid.
CO4: Acquire knowledge about configurations and control aspects of Hybrid microgrid.
CO5: Learn the protection aspects of microgrid.

REFERENCES:

1. H. Bevrani, Bruno Francois and ToshifumiIse, "Microgrid Dynamics and Control", Wiley, 2017.
2. Li Fusheng, Li Ruisheng and Zhou Fengquan, "Microgrid Technology and Engineering Application", Elsevier, 2016.
3. M.S. Mahmoud, "Microgrid - Advanced Control Methods and Renewable Energy System Integration", Elsevier, 2017.
4. Farzam Nejabatkhah and Yun Wei Li, "Overview of Power Management Strategies of Hybrid AC/DC Microgrid", IEEE Transactions on Power Electronics, 2014.
5. Papai Ray, Monalisa Biswal, "Microgrid: Operation, Control, Monitoring and Protection", Springer Singapore, 2020.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	-	3	1
CO2	2	1	3	-	3	1
CO3	2	1	3	-	3	1
CO4	2	1	3	-	3	1
CO5	2	1	3	-	3	1
Average	**2**	**1**	**3**	**-**	**3**	**1**

Attested

PW3052 ELECTRIC VEHICLES AND POWER MANAGEMENT **LT P C**
3 0 0 3

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS 9

History of Evolution of Electric Vehicles (EV) - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power Train Components and Sizing, Gears, Clutches, Transmission and Brakes

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9

Fundamentals of Vehicle Mechanics - Tractive Force, Power and Energy Requirements for Standard Drive Cycles of HEV's - Motor Torque - Power Rating and Battery Capacity

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9

Speed control for Constant Torque, Constant HP operation of all Electric Motors - DC/DC chopper based Four Quadrant Operation of DC Motor Drives, Inverter-based V/f Operation (motoring and braking) of Induction Motor Drives, Vector Control Operation of Induction Motor and PMSM, Brushless DC Motor Drives, Switched Reluctance Motor (SRM) Drives

UNIT IV ENERGY STORAGE SYSTEMS 9

Battery: Principle of operation, Types, Estimation Of Parameters, Battery Modeling, SOC of Battery, Traction Batteries and their capacity for Standard Drive Cycles, Vehicle to Grid operation of EV's - Alternate sources: Fuel cells, Ultra capacitors, Fly wheels

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT 9

HEV Supervisory Control - Selection of modes - Power Spilt Mode - Parallel Mode - Engine Brake Mode - Regeneration Mode - Series Parallel Mode - Energy Management of HEV's

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:
CO1: Learn the electric vehicle architecture and power train components.
CO2: Acquire the concepts of dynamics of Electrical Vehicles.
CO3: Understand the vehicle control for Standard Drive Cycles of Hybrid Electrical Vehicles (HEVs).
CO4: Ability to model and understand the Energy Storage Systems for EV.
CO5: Acquire the knowledge of different modes and Energy Management in HEVs.

REFERENCES:

1. Iqbal Husain, “Electric and Hybrid Electric Vehicles”, First Edition, CRC Press, 2011
2. Wei Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, Wiley, 2017
3. James Larminie and John Lowry, “Electric Vehicle Technology Explained”, Second Edition, 2012
4. Mehredad Ehsani, Yimi Gao, Stefano Longo and Kambiz Ebrahimi,” Modern Electric, Hybrid Electric and Fuel cell Vehicles”, Third edition, CRC Press, 2019
5. Jingsheng Yu and Vladimir V. Vantsevich, “Control Application of Vehicle Dynamics”, First Edition, CRC Press, 2021

MAPPING OF COs WITH POs AND PSOs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	-	3
CO2	3	1	2	1	-	3
CO3	3	1	2	1	-	3
CO4	3	1	2	1	-	3
CO5	3	1	2	1	-	3
Average	**3**	**1**	**2**	**1**	**-**	**3**

ET3055 EMBEDDED NETWORKING AND AUTOMATION OF ELECTRICAL SYSTEM **L T P C 3 0 0 3**

UNIT I BUILDING SYSTEM AUTOMATION 9

Sensor Types & Characteristics: Sensing Voltage, Current, flux, Torque, Position, Proximity, Accelerometer - Data acquisition system - Signal conditioning circuit design - Uc Based & PC based data acquisition - uC for automation and protection of electrical appliances -processor based digital controllers for switching Actuators: Stepper motors, Relays -System automation with multi-channel Instrumentation and interface .

UNIT II EMBEDDED NETWORKING OF INSTRUMENT CLUSTER 9

Embedded Networking: Introduction - Cluster of Instruments in System - Comparison of bus protocols - RS 232C - embedded ethernet - MOD bus and CAN bus, LIN BUS - Introduction to WSN - Commercially available sensor nodes - Zigbee protocol - Network Topology Energy efficient MAC protocols - SMAC - Data Centric routing Applications of sensor networks - Database perspective on sensor networks - IoT Applications.

UNIT III AUTOMATION OF SUBSTATION 9

Substation automation - Distribution SCADA system principles - role of PMU, RTU, IEDs, BUS for smart Substation automation- Introduction to Role of IEC 61850, IEEEC37.118 std- Interoperability and IEC 61850 - challenges of Substations in Smart Grid - challenges of Energy Storage and Distribution Systems monitoring - Communication Challenges in monitoring electric utility asset.
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UNIT IV METERING OF SMART GRID 9

Characteristics of Smart Grid - Generation by Renewable Energy Sources based on solar grid - Challenges in Smart Grid and Microgrids - electrical measurements with AMI - Smart meters for EV plug in electric vehicles power management - Home Area Net metering and Demand side Energy Management applications.

UNIT V SMART METERS FOR PQ MONITORING 9

Power Quality issues of Grid connected Renewable Energy Sources -Smart meters for Power Quality monitoring and Control - Power Quality issues -Surges - Flicker - Interharmonics - Transients - Power Quality Benchmarking - Power Quality Meters- Meter data management In Smart Grid-, communication enabled Power Quality metering

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TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to
CO1: Demonstrate criteria of choice of sensors, components to build meters.
CO2: Illustrate the demand for BUS communication protocols are introduced
CO3: Analyse the need and standards in Substation automation
CO4: Deployment of PAN for metering networked commercial applications
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded networked communications.

REFERENCES:

1. Control and automation of electrical power distribution systems, James Northcote-Green, Robert Wilson, CRC, Taylor and Francis, 2006
2. Krzysztof Iniewski," Smart Grid, Infrastructure& Networking", TMcGH,2012
3. Robert Faludi," Building Wireless Sensor Networks,O'Reilly,2011
4. Mohammad Ilyas And Imad Mahgoub, 'Handbook of sensor Networks: Compact wireless and wired sensing systems', CRC Press,2005
5. Shih-Lin Wu,Yu-Chee Tseng,{"Wireless Ad Hoc Networking, PAN, LAN, SAN, Aurebach Pub,2012
6. Sanjay Gupta, "Virtual Instrumentation, LABVIEW", TMH, New Delhi, 2003
7. Ernest O. Doeblin and Dhanesh N Manik, "Measurement Systems - Application and Design", 5th Edition, TMH, 2007.
8. Bhaskar Krishnamachari, 'Networking wireless sensors', Cambridge press 2005

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	2	1
CO2	1	-	2	2	3	1
CO3	3	1	2	-	-	-
CO4	2	-	2	3	3	2
CO5	2	1	2	-	-	3
Average	**2.2**	**1**	**2**	**2**	**2.66**	**1.75**

ET3067 **UNMANNED AERIAL VEHICLE** **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO UAV 9

Overview and background - History of UAV -classification - societal impact and future outlook Unmanned Aerial System (UAS) components - models and prototypes - System Composition - Applications

UNIT II THE DESIGN OF UAV SYSTEMS 9

Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations - Characteristics of Aircraft Types - Design Standards - Regulatories and regulations - Design for Stealth - control surfaces - specifications.

UNIT III HARDWARES FOR UAVs 9

Real time Embedded processors for UAVs – sensors - servos - accelerometer – gyros -actuators - power supply - integration, installation, configuration, and testing - MEMS/NEMS sensors and actuators for UAVs - Autopilot - AGL.

UNIT IV COMMUNICATION PAYLOADS AND CONTROLS 9

Payloads-Telemetry – tracking - Aerial photography - controls - PID feedback- radio control frequency range - modems - memory system – simulation - ground test – analysis - trouble shooting.

UNIT V THE DEVELOPMENT OF UAV SYSTEMS 9

Waypoints navigation - ground control software - System Ground Testing - System In - flight Testing - Mini, Micro and Nano UAVs - Case study: Agriculture- Health- Surveying- Disaster Management and Defense.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Identify different hardware for UAV.

CO2: Determine preliminary design requirements for an unmanned aerial vehicle.

CO3: Design UAV system.

CO4: Identify and integrate various systems of unmanned aerial vehicle.

CO5: Design micro aerial vehicle systems by considering practical limitations.

REFERENCES:

1. Reg Austin “Unmanned Aircraft Systems UAV design, development and deployment”, Wiley, 2010.
2. Paul G Fahlstrom, Thomas J Gleason, “Introduction to UAV Systems”, UAV Systems, Inc, 1998
3. Dr. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company, 2001
4. Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy”, Springer, 2007
5. Robert C. Nelson, “Flight Stability and Automatic Control”, McGraw-Hill, Inc, 1998.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	2	-	-	2
CO2	3	3	3	-	-	2
CO3	3	3	3	3	3	3
CO4	-	-	2	3	3	2
CO5	3	-	3	3	3	3
Average	**2.5**	**3**	**2.6**	**3**	**3**	**2.4**

ET3054 EMBEDDED CONTROLLERS FOR EV APPLICATIONS **LT P C**
3 0 0 3

UNIT I EMBEDDED SYSTEM AND ELECTRIC VEHICLES ARCHITECTURE 9

Overview of Electric vehicles - Evolution of Electric Vehicles - Definition and types of EV (BEV, HEV, PHEV) - EV Architecture - EV Components and Subsystems - Advantages and challenges of EV - Comparison of EV with Internal Combustion Engine - Emerging trends in EV Technologies- Embedded System Architecture- Open ECU-AUTOSAR.

UNIT II POWERTRAIN CONTROL AND ENERGY MANAGEMENT SYSTEM IN EV 9

Powertrain Components - Powertrain control and Optimization - Embedded Controllers for motor control- ECU for Energy Management system - Battery Management System (BMS) - Battery State of Charge (SoC) Estimation - Energy Consumption Monitoring - Charging Optimization- ECU for Charging.

UNIT III COMMUNICATION AND CONNECTIVITY IN EV 9

Vehicle-to-Vehicle Technology(V2V) - Vehicle-to-Infrastructure(V2I) Technology Communication - Communication Protocol (CAN, LIN, Ethernet, etc.) - Wireless Charging and Communication for EV - Over the air (OTA) Updates and Remote diagnostics in EV.

UNIT IV FAULT MONITORING AND DIAGNOSTICS IN EV 9

Overview of Fault Monitoring and Diagnostics in EV - Fault detection techniques - Fault Monitoring in Electric Powertrain - Fault Monitoring in Charging Infrastructure - On-board Diagnostics (OBD) with self-check mechanisms - Diagnostics and Reporting - Case studies on fault detection, Diagnosis and Resolution

UNIT V SAFETY, SECURITY AND AUTONOMOUS SYSTEMS IN EV 9

Safety Standards and Regulations for EVs - Functional Safety and ISO26262 in EV -Cybersecurity in EVs - Threats and Countermeasures - Antilock Braking system(ABS) -Electronic Stability Control (ESC) - Advanced driver Assistance systems (ADAS) -Autonomous Driving in EVs.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Able to understand the principles and components of electric vehicles, including powertrain systems, energy storage systems, motor controllers, and vehicle dynamics.

CO2: Able to learn about the unique requirements and challenges associated with embedded controllers in EV applications.

CO3: able to learn about hardware platforms, such as microcontrollers and microprocessors, as well as communication protocols and interfaces used for control and monitoring of EV.

CO4: Able to gain hands-on experience in developing embedded control algorithms for various EV systems, including motor control, battery management, regenerative braking, and charging systems.

CO5: able to understand the integration of embedded controllers in autonomous electric vehicles

REFERENCES:

1."Embedded Control Systems for Electric Machines" by Jiming Wang, Shan Chai, and Shuxin Zhou (Published in 2011)

2."Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain (Published in 2013)

3."Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure, and the Market" by Gérard-André Capolino (Published in 2010)

4."Embedded Systems for Electric Vehicles" by Jürgen Valldorf and Wolfgang Gessner (Published in 2011)

5."Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad, J. Miguel Guerrero, and Juan de la Casa (Published in 2016)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

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ET3059	INTELLIGENT SYSTEM DESIGN	L T P C 3 0 0 3

UNIT I INTELLIGENT SYSTEMS AND PYTHON PROGRAMMING 9

Introduction to Machine Learning and Deep Learning - Performance Improvement with Machine Learning - Building Intelligent Systems - Introduction to Python -Python Programming

UNIT II PYTHON FOR ML 9

Python Application of Linear Regression and Polynomial Regression using SciPy - Interpolation, Overfitting and Underfitting concepts & examples using SciPy - Clustering and Classification using Python.

UNIT III EMERGING TRENDS IN HARDWARE ARCHITECTURES FOR DEEP LEARNING 9

Quantization and Precision Reduction Techniques - Hardware aware neural Architecture. Hardware-software co-design for deep learning systems Memory hierarchy and cache optimization for deep learning Parallelization and distributed training of deep learning models Energy-efficient deep learning hardware architectures Hardware acceleration for specific deep learning applications (e.g., natural language processing, computer vision)

UNIT IV PYTHON FOR DL 9

Python Applications for DL - Python for CNN and YOLO

UNIT V CASE STUDIES 9

Development of Intelligent System for Power system protection - Smart Energy - IOE- Motor control - BMS - Intelligent systems for Industry 4.0 and Industry 5.0

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability in

CO1: Able to gain proficiency in the Python programming language and learn how to apply it in the context of intelligent systems

CO2: Able to learn Python libraries such as NumPy, Pandas, and scikit-learn to preprocess data, build and train Machine Learning models, and evaluate their performance

CO3: Able to learn Deep Learning libraries such as TensorFlow or PyTorch to build, train, and evaluate Deep Learning models for tasks such as image classification, natural language processing, and computer vision.

CO4: Able to learn hardware components, such as processors, memory, and accelerators, and how they are integrated.

CO5: Able to learn intelligent systems implementations, examine their design choices, evaluate their performance, and understand the challenges.

REFERENCES:

1."Intelligent Systems: Principles, Paradigms, and Pragmatics" by Rajendra P. Srivastava (Published in 2013)
2."Intelligent Systems: A Modern Approach" by Thomas Bäck, David B. Fogel, and Zbigniew Michalewicz (Published in 2000)
3."Intelligent Systems: Modeling, Optimization, and Control" by Grzegorz Bocewicz and Konrad Jackowski (Published in 2016)
4."Intelligent Systems: Architecture, Design, and Control" by Janos Sztipanovits and Gabor Karsai (Published in 2018)
5."Intelligent Systems: Concepts and Applications" by Veera M. Boddu (Published in 2017)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

ET3052 BLOCKCHAIN TECHNOLOGIES **L T P C**
3 0 0 3

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain-Hardware architecture for Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

UNIT III INTRODUCTION TO ETHEREUM 9

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.

UNIT IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING 10

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

UNIT V BLOCKCHAIN APPLICATIONS 8

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to
CO1: Understand and explore the working of Blockchain technology
CO2: Analyze the working of Smart Contracts
CO3: Understand and analyze the working of Hyperledger
CO4: Apply the learning of solidity to build de-centralized apps on Ethereum
CO5: Develop applications on Blockchain

REFERENCES:

1. Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained", Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction" Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O'Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, "Mastering Ethereum: Building Smart Contracts and Dapps", O'Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Average	**1**	**-**	**2**	**2**	**1.5**	**-**

ET3051 **BIG DATA ANALYTICS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO BIG DATA 9

Introduction to Big Data Platform - Challenges of Conventional Systems - Intelligent data analysis - Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT II SEARCH METHODS AND VISUALIZATION 9

Search by simulated Annealing - Stochastic, Adaptive search by Evaluation - Evaluation Strategies - Genetic Algorithm - Genetic Programming - Visualization - Classification of Visual Data Analysis Techniques - Data Types - Visualization Techniques - Interaction techniques - Specific Visual data analysis Techniques

UNIT III MINING DATA STREAMS 9

Introduction To Streams Concepts - Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream - Filtering Streams - Counting Distinct Elements in a Stream - Estimating Moments - Counting Oneness in a Window - Decaying Window - Real time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

UNIT IV FRAMEWORKS 9

MapReduce - Hadoop, Hive, MapR - Sharding - NoSQL Databases - S3 - Hadoop Distributed File Systems - Case Study - Preventing Private Information Inference Attacks on Social Networks - Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

UNIT V R LANGUAGE 9

Overview, Programming structures: Control statements - Operators -Functions - Environment and scope issues - Recursion - Replacement functions, R data structures: Vectors - Matrices and arrays - Lists - Data frames - Classes, Input/output, String manipulations

TOTAL:45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to:
CO1: Understand the basics of big data analytics
CO2: Ability to use Hadoop, Map Reduce Framework.
CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.
CO4: Gain knowledge on R language
CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

REFERENCES:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Average	**1**	**-**	**2**	**2**	**1.5**	**-**

ET3251 AUTOMOTIVE EMBEDDED SYSTEMS **LT P C**
3 0 0 3

UNIT I ELECTRONIC ENGINE CONTROL SYSTEMS 9

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Automotive microcontrollers - Electronic control Unit - Hardware & software selection and requirements for Automotive applications – open source ECU - RTOS - Concept for Engine management-Standards; Introduction to AUTOSAR and Introduction to Society SAE - Functional safety ISO 26262 - Simulation and modeling of automotive system components.

UNIT II SENSORS AND ACTUATORS FOR AUTOMOTIVES 9

Review of sensors- sensors interface to the ECU, conventional sensors and actuators, Modern sensor and actuators - LIDAR sensor- smart sensors- MEMS/NEMS sensors and actuators for automotive applications.

UNIT III VEHICLE MANAGEMENT SYSTEMS 9

Electronic Engine Control - engine mapping, air/fuel ratio spark timing control strategy, fuel control, electronic ignition - Adaptive cruise control - speed control - anti-locking braking system - electronic suspension - electronic steering, Automatic wiper control - body control system; Vehicle system schematic for interfacing with EMS, ECU. Energy Management system for electric vehicles - Battery management system, power management system-electrically assisted power steering system - Adaptive lighting system - Safety and Collision Avoidance.

UNIT IV ONBOARD DIAGONSTICS AND TELEMATICS 9

On board diagnosis of vehicles - System diagnostic standards and regulation requirements Vehicle communication protocols Bluetooth, CAN, LIN, FLEXRAY, MOST, KWP2000 and recent trends in vehicle communications - Navigation - Connected Cars technology - Tracking - Security for data communication - dashboard display and Virtual Instrumentation, multimedia electronics - Role of IOT in Automotive systems

UNIT V ELECTRIC VEHICLES 9

Electric vehicles – Components - Plug in Electrical vehicle - V2G - Charging station – Aggregators - Fuel cells/Solar powered vehicles - Autonomous vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Insight into the significance of the role of embedded system for automotive applications.

CO2: Illustrate the need, selection of sensors and actuators and interfacing with ECU

CO3: Develop the Embedded concepts for vehicle management and control systems.

CO4: Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs

CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.

REFERENCES:

1. William B. Ribbens, "Understanding Automotive Electronics", Elseiver,2012
2. Ali Emedi, Mehrdedehsani, John M Miller, "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 2004.
3. L.Vlacic, M.Parent, F.Harahima," Intelligent Vehicle Technologies", SAE International,2001.
4. Jack Erjavec,JeffArias, "Alternate Fuel Technology-Electric, Hybrid& Fuel Cell Vehicles", Cengage , 2012.
5. Electronic Engine Control technology - Ronald K Jurgen Chilton's guide to Fuel Injection - Ford.
6. Automotive Electricals/Electronics System and Components, Tom Denton, $3^{rd.}$ Edition, 2004.
7. Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1 edition, March 30, 2000.
8. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 4^{th} Edition, 2004.
9. Automotive Hand Book, Robert Bosch, Bently Publishers, 1997.
10. Jurgen, R., Automotive Electronics Hand Book.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	1	1	-	2
CO2	2	3	2	2	2	3
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	2
Average	**2.75**	**2.8**	**2.4**	**2.4**	**2.75**	**2.2**

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CO3054 INTELLIGENT TRANSPORTATION SYSTEMS **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO INTELLIGENT TRANSPORTATION SYSTEMS 9

Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

UNIT II TELECOMMUNICATIONS IN ITS 9

Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System

UNIT III ITS FUNCTIONAL AREAS 9

Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced RuralTransportation Systems (ARTS).

UNIT IV ITS USER NEEDS AND SERVICES 9

Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

UNIT V AUTOMATED HIGHWAY SYSTEMS 9

Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developedcountries, ITS in developing countries, Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students should be able to:
CO1: understand the sensor technologies
CO2: understand the communication techniques
CO3: apply the various ITS methodologies
CO4: understand the user needs
CO5: define the significance of ITS under Indian conditions

REFERENCES:

1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by KanPaul Chen, John Miles.
2. Sussman, J. M., Perspective on ITS, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).
4. Chowdhary, M.A. and A Sadek, Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003.
5. Williams, B., Intelligent transportation systems standards. Artech House, London,2008.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	3	3
CO2	1	1	3	-	2	2
CO3	2	-	1	-	1	2
CO4	-	1	-	-	-	-
CO5	1	1	-	-	-	-
Average	**1.5**	**1**	**2**	**1**	**2**	**2.3**

CO3059 WIRELESS SENSOR NETWORKS **L T P C**
3 0 0 3

UNIT I ARCHITECTURE OF WIRELESS SENSOR NETWORKS 9
Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture — Hardware components, energy consumption of sensor nodes, Network architecture — Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks.

UNIT II FUNDAMENTALS OF WIRELESS COMMUNICATION AND CHANNEL CHARACTERISTICS 9
Wireless channel and communication fundamentals — frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation, power management.

UNIT III MAC AND LINK LAYER PROTOCOLS 9
MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols — fundamentals task and requirements, error control, framing, link management

UNIT IV METHODS OF NETWORKING COMMUNICATION, ROUTING, DESIGN 9
Gossiping and agent-based uni-cast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data –centric and content-based networking – Data –centric routing, Data aggregation, Data-centric storage, Higher layer design issue

UNIT V SENSOR NETWORK APPLICATIONS 9
Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Understand challenges, architectural components, energy considerations, network scenarios, and design principles of wireless sensor networks,

CO2: Equip students with a comprehensive understanding of wireless communication fundamentals and their specific application in wireless sensor networks.

CO3: Design, analyse, and implement efficient MAC protocols for reliable communication in wireless environments.

CO4: Gain advanced knowledge in gossiping, energy-efficient communication, geographic routing, and data-centric networking.

CO5: Design and implement wireless sensor network solutions for real-world applications.

REFERENCES

1. Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Elsevier, 2004.
2. Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2007.
3. Ivan Stojmenovic, "Handbook of Sensor Networks: Algorithms and Architectures", Wiley, 2005.
4. Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks: Technology, Protocols and Applications", John Wiley, 2007.
5. Bhaskar Krishnamachari, "Networking Wireless Sensors", Cambridge University Press, 2011.

MAPPING OF COs WITH POs AND PSOs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	1
AVg.	**3**	**3**	**3**	**2**	**2**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

PS3052 DISTRIBUTED GENERATION AND MICRO GRID

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO DISTRIBUTED GENERATION 9

DG definition - Reasons for distributed generation-Benefits of integration - Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system-Impact of distributed generation on central generation

UNIT II DISTRIBUTED ENERGY RESOURCES 9

Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)- Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

UNIT III DG PLANNING AND PROTECTION 9

Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation-Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

UNIT IV AC MICROGRID 9

Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

UNIT V DC MICROGRID 9

Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to:
CO1: Understand the concepts of Distributed Generation and Microgrids.
CO2: Gain Knowledge about the various DG resources.
CO3: Familiarize with the planning and protection schemes of Distributed Generation.
CO4: Learn the concept of Microgrid and its mode of operation.
CO5: Acquire knowledge on the impacts of Microgrid.

REFERENCES:

1. Nick Jenkins, JanakaEkanayake ,GoranStrbac , “Distributed Generation”, Institution of Engineering and Technology, London, UK,2010.

2. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, The Institution of Engineering and Technology, London, United Kingdom, 2009.
3. Math H. Bollen ,Fainan Hassan, “Integration of Distributed Generation in the Power System”, John Wiley &Sons, New Jersey, 2011.
4. Magdi S. Mahmoud, Fouad M. AL-Sunni, “Control and Optimization of Distributed Generation Systems”, Springer International Publishing, Switzerland, 2015.
5. NadarajahMithulananthan, Duong Quoc Hung, Kwang Y. Lee, “Intelligent Network Integration of Distributed Renewable Generation”, Springer International Publishing, Switzerland, 2017.
6. Ali K., M.N. Marwali, Min Dai, “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley and sons, New Jersey, 2010.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	1	1	2	1	-
CO3	1	2	-	1	1	1
CO4	1	1	2	1	2	-
CO5	1	-	1	1	-	1
Average	**1**	**1.33**	**1.33**	**1.2**	**1.33**	**1**

PS3252 SMART GRID L T P C
3 0 0 3

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (TRANSMISSION) 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

UNIT III SMART GRID TECHNOLOGIES (DISTRIBUTION) 9

DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric Vehicles (PHEV).

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT V COMMUNICATION PROTOCOLS FOR POWER SYSTEM AUTOMATION 9

Introduction to Communication Protocol, Comparison of Communication media and different communication network topologies Description of Different Communication Protocol - Physical based Protocol(RS-232,RS-485) - Layered Based Protocol(IEC-61850 - Substation Automation) (C37.118 - Wide Area Monitoring and Protection),(DNP3 - Distribution Automation),MODBUS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1: Understand on the concepts of Smart Grid and its present developments.

CO2: Analyze about different Smart Grid transmission technologies.

CO3: Analyze about different Smart Grid distribution technologies.

CO4: Acquire knowledge about different smart meters and advanced metering infrastructure.

CO5: Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

REFERENCES:

1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”,CRC Press 2016.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”,Wiley.
3. Vehbi C. Gungor, DilanSahin, TaskinKocak, SalihErgut, ConcettinaBuccella, Carlo Cecati and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey” , IEEE Transaction on Smart Grid

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	2	-	1	1	1
CO3	1	2	-	1	2	-
CO4	1	-	-	1	1	2
CO5	1	2	2	1	-	2
Average	**1**	**2**	**2**	**1**	**1.33**	**1.67**

PS3054 WIND ENERGY CONVERSION SYSTEMS **L T P C**
3 0 0 3

UNITI INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1: Attain knowledge on the basic concepts of Wind energy conversion system.

CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine

CO3: Develop more understanding on the design of Fixed speed system

CO4: Study about the need of Variable speed system and its modelling.

CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall,1990
2. S.N.Bhadra, D.Kastha,S.Banerjee, "Wind Electrical Systems", Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group,2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley &Sons,1997.
6. S.Heir "Grid Integration of WECS", Wiley1998.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	-	2
CO2	3	1	2	2	2	2
CO3	3	1	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	2	2	3
Average	**2.6**	**1.5**	**2.2**	**2.4**	**2**	**2.2**

PE3151 **ANALYSIS OF POWER CONVERTERS** **L T P C**
3 0 0 3

UNIT I SINGLE PHASE AC-DC CONVERTER 9

Static Characteristics of power diode and SCR, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER 9

Semi and fully controlled converter with R, R-L, R-L-E - loads and freewheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and overlap-12 pulse converter

UNIT III SINGLE PHASE INVERTERS 9

Introduction to self-commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS-VSR operation

UNIT IV THREE PHASE INVERTERS 9

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application to drive system – Current source inverters.

UNIT V MODERN INVERTERS 9

Multilevel concept – diode clamped – flying capacitor – cascaded type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase &Three phase Impedance source inverters - Filters.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to:

CO1: Ability to acquire and apply knowledge of mathematics in power converter analysis.
CO2: Ability to model, analyze and understand power electronic systems and equipment.
CO3: Ability to formulate, design and simulate phase-controlled rectifiers for generic load and for machine loads.
CO4: Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads.
CO5: Ability for device selection and calculation of performance parameters of power converters under various operating modes.

TEXT BOOKS:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ", Prentice Hall India, fourth Edition, New Delhi, 2014.
2. Jai P. Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
3. Bimal.K.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan, T.M.Undeland and W.P.Robbins, “Power Electronics: converters, Application and design” John Wiley and sons. Wiley India edition, 2006.
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press-1998.

REFERENCES:

1. P.C.Sen, “Modern Power Electronics”, Wheeler Publishing Co,First Edition, New Delhi, 1998.
2. P.S.Bimbhra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003.
3. Bin Wu, Mehdi Narimani, "High-power Converters and AC Drives", Wiley, 2nd Edition, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	1	2	1	3	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	2
Average	2	1.8	2	1.8	3	1.6

PE3053 POWER QUALITY L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction – Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non-linear loads –single phase sinusoidal, non-sinusoidal source – supplying linear and non-linear load – three phase Balance system – three phase unbalanced system – three phase unbalanced and distorted source supplying non-linear loads – concept of PF – three phase three wire – three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction– analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced –Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified power quality conditioner.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to:

CO1: Ability to understand consequences of Power quality issues.
CO2: Ability to conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.
CO3: Ability to design passive filter for load compensation.
CO4: Ability to design active filters for load compensation.
CO5: Ability to understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.

TEXTBOOKS:

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994 (Second edition).

REFERENCES:

1. R.C.Duggan Electric Power Systems Quality, Tata MC Graw Hill Publishers, Third Edition,
2. Arrillga Power System Harmonics, John Wiely and Sons, 2003 Second Edition.
3. Derek A.Paice Power Electronic Converter Harmonics, Wiley – IEE Press 1999, 18th Edition.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1	2	-
CO2	3	-	2	1	1	-
CO3	3	1	3	3	-	-
CO4	3	-	3	3	-	-
CO5	3	1	1	2	3	-
Average	**2.8**	**1**	**2**	**2**	**2**	**-**

HV3052 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- EMI predictions and modelling, Methods of eliminating interferences and noise mitigation

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive coupling, inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems -hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES **9**

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards - FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to:

CO1: Ability to understand the types and sources of EMI.

CO2: Ability to understand the needs of grounding and cabling.

CO3: Ability to understand the design concept of filtering and shielding.

CO4: Ability to study the effect of EMI in elements and circuits.

CO5: Ability to know about the effects of electrostatic discharge and testing techniques.

REFERENCES:

1. V.P. Kodali, "Engineering Electromagnetic Compatibility", S. Chand, 1996.
2. Henry W.Ott, " Noise reduction techniques in electronic systems", John Wiley & Sons, 1989.
3. Bernhard Keiser, "Principles of Electro-magnetic Compatibility", Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4. Bridges, J.E Milleta J. and Ricketts.L.W., "EMP Radiation and Protective techniques", John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, "Series on Electromagnetic Interference and Compatibility", Vol.
6. Weston David A., "Electromagnetic Compatibility, Principles and Applications", 1991.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	2
CO2	3	2	2	3	2	2
CO3	3	2	2	2	1	3
CO4	3	2	2	2	2	2
CO5	3	2	2	3	2	3
Average	**3**	**2**	**2**	**2.2**	**1.6**	**2.4**

HV3051 **DESIGN OF SUBSTATIONS** **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO AIS AND GIS **9**

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS **9**

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes - single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus.

UNIT III INSULATION COORDINATION OF AIS AND GIS **9**

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC standards.

UNIT IV GROUNDING AND SHIELDING **9**

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by ground wires and lightning masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS **9**

Introduction – origin of VFTO - Disconnector switching — propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO - Controlling methods

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to:
CO1: Ability to understand the fundamental components of AIS AND GIS.
CO2: Ability to understand the layout of AIS and GIS.
CO3: Ability to understand the insulation coordination of AIS and GIS.
CO4: Ability to understand the significance of grounding and shielding.
CO5: Ability to know about the effects of very fast transients in Substation

REFERENCES:

1. Andrew R. Hileman, “Insulation coordination for power systems”, Taylor and Francis, 1999.
2. M.S. Naidu, “Gas Insulation Substations”, I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, “Surges in high voltage networks” Plenum Press,New York, 1980.
4. “Power Engineer’s handbook”, TNEB Association.
5. PritindraChowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2008.
6. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.

7. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. on Power Apparatus and Systems, August 1953
8. Hermann Koch , “Gas Insulated Substations”, Wiley-IEEE Press,2014
9. IEEE Std 80, IEEE Guide for Safety in AC Substation Grounding - 2013
10. IS Standard 3043 “CODE OF PRACTICE FOR EARTHING (First Revision)”; 1987.
11. Working Group JWG B3.35/CIRED, “Substation earthing system design optimisation through the application of quantified risk analysis” CIGRE 749,2018.
12. CIGRE Green Book, “Substation”, Study Committee B3, PP 83 -155.
13. Working Group WG 23.03, “General guidelines for the design of outdoor AC substations. (2nd version)” CIGRE 161, 2000.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	1	1	-	1
CO2	1	3	1	1	-	1
CO3	2	3	3	1	-	3
CO4	1	1	1	2	-	1
CO5	3	2	1	2	-	1
Average	**1.6**	**2.4**	**1.4**	**1.4**	**-**	**1.4**

HV3152 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **LT P C 3 0 0 3**

UNIT I INTRODUCTION 9

Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace’s, Poisson’s and Helmholtz’s equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9

Concept of FEM - Integral Formulation – Energy minimization – Discretization – Shape functions – Stiffness matrix –1D and 2D planar and axial symmetry problems

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

UNIT IV COMPUTATION USING FEM PACKAGES 9

Elements of FEM package-preprocessor, processor, post processor –computation of Electric Field – Energy- Capacitance, Magnetic Field – Linked Flux – Inductance – Force – Torque , Skin effect – Resistance

UNIT V ELECTROMAGNETIC FIELD MODELLING AND ANALYSIS 9

Three phase transmission lines, Magnetic actuators, Transformers, Insulators, Rotating machines.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1 explain the concepts of electromagnetic field theory and energy conversion
CO2 formulate and compute Electromagnetic Field problems from Maxwell’s equations
CO3 formulate FEM problems from the fundamental concepts
CO4 compute the respective fields and circuit parameters using FEM (post processing)
CO5 check and optimize the design of electrical power equipment

REFERENCES:

1. Matthew. N.O. Sadiku, S.V. Kulkarni, “Elements of Electromagnetics”, Seventh Edition, Oxford University Press, Asian Edition 2021
2. Matthew. N.O. Sadiku ”Numerical techniques in electromagnetics”, Second Edition, CRC Press,2000.
3. Sivaji Chakravorti, “ Elelctric Field Analysis”, CRC Press (Taylor & Francis), USA, 2015
4. Nicola Bianchi, “Electrical Machine analysis using Finite Elements”, Taylor and Francis Group, CRC Publishers, 2005.
5. S S Rao, “ The Finite Element Method in Engineering”, Fifth Edition ,Butterworth-heinmann,2010.
6. J.N.Reddy, “ An Introduction to the Finite Element Method”. Fourth Edition, Mc Graw Hill Publications, 2019.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	3	-	2
CO2	2	1	-	3	-	2
CO3	2	1	-	3	-	2
CO4	2	1	1	3	-	3
CO5	2	1	3	3	-	3
Average	**2**	**1**	**2**	**3**	**-**	**2.4**

MA3156 **APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS** **L T P C**
4 0 0 4

UNIT I MATRIX THEORY 12

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition

UNIT II CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries - Direct methods: Ritz and Kantorovich methods

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 12

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER SERIES 12

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1: Apply the concepts of Matrix theory in Electrical Engineering problems.

CO2: Use calculus of variation techniques to solve various engineering problems.

CO3: Solve electrical engineering problems involving one-dimensional random variables.

CO4: Formulate and solve linear programming problems in electrical engineering.

CO5: To solve engineering problems using Fourier series techniques.

REFERENCES:

1. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 2003.
3. Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, 8th Edition, New Delhi, 2015.
6. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), Boston, 2014.

7. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Richard Bronson, “Matrix Operation”, Schaum’s outline series, McGraw Hill, 2nd Edition, New York, 2011.
9. Taha, H.A., “Operations Research, An introduction”, Pearson education, 10th Edition, New Delhi, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	**3**	**3**	**3**	**3**	**2**	**2**

MA3159 NUMERICAL METHODS AND OPTIMIZATION TECHNIQUES **L T P C**
4 0 0 4

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method

UNIT II FINITE DIFFERENCE METHOD FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method– Wave equation: Explicit scheme- Stability- Laplace and Poisson’s equations in a rectangular region: Five point finite difference schemes, Leibmann’s iterative methods

UNIT III FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

UNIT IV LINEAR PROGRAMMING 12

Two variable LP model - Graphical solution - Simplex method - Special cases in the simplex method - Transportation and Assignment problem

UNIT V DETERMINISTIC DYNAMIC PROGRAMMING 12

Recursive Nature of Dynamic Programming Computations - Forward and Backward Recursion - Selected Dynamic Programming Applications

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

CO1: Solve the simultaneous ordinary differential equations (Initial Value Problem) numerically.

CO2: Solve numerically set of Partial differential equations.

CO3: Solve the set of PDEs by finite element method.

CO4: Obtain the most optimal solution for a constrained problem.

CO5: Handle the Dynamic Programming problems using forward and backward recursion.

REFERENCES:

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	**3**	**3**	**3**	**3**	**2**	**2**