List of Elective Courses in aligned with all SDGs

(Professional & Open electives courses mapped with SDGs and syllabus)

KPR Institute of Engineering and Technology
Centre for Academic Courses
Coimbatore

S.N	DEPT.	SDG COURSE YEAR	SDG COURSE SEM	SUBJECT CODE	SUBJECT TITLES	SDGs
1	CY	I	I/II	U25RMCC04	Environmental Governance and Sustainability	SDG 1, SDG 4, SDG 17
2	CY	II	IV	U25CYX01	Organic Farming and Sustainable Agricultural Technologies	SDG 2, SDG 12, SDG 13,SDG 15
3	CY	II	IV	U25CYX02	Air Quality, Pollution and Control Techniques	SDG 3, SDG 9, SDG 11,SDG 13
4	CY	II	IV	U21CYX01	Air pollution and control	SDG 3, SDG 9, SDG 11,SDG 13
5	CY	II	V	U21CYX05	Waste management and Resource Recovery	SDG 6, SDG 11, SDG 12,SDG 13
6	CY	III	V	U21CYX07	Food Engineering and Technology	SDG 2, SDG 9, SDG 12
7	CY	IV	VII	U21CYX06	Chemical Aspects of Food Adulteration	SDG 2, SDG 3, SDG 9,SDG 12
8	CH	III/IV	IV/VI	U21CHP25	Water conservation and management	SDG 6, SDG 12, SDG 13, SDG 15
9	CH	III/IV	IV/VI	U21CHP27	Wastewater Treatment	SDG 6, SDG 3, SDG 12, SDG 14
10	CH	III/IV	IV/VI	U21CHP28	Waste Management	SDG 11, SDG 12, SDG 14, SDG 15
11	CH	III/IV	IV/VI	U21CHP30	Air Pollution Monitoring and Control	SDG 3, SDG 11, SDG 12, SDG 13
12	CH	III/IV	IV/VI	U21CHP23	Renewable and Non-Renewable Energy Resources	SDG 7, SDG 9, SDG 12, SDG 13

13	CH	III/IV	IV/VI	U21CHP20	Energy Efficiency in Electrical and Thermal Utilities	SDG 7, SDG 9, SDG 12, SDG 13
14	CH	III/IV	IV/VI	U21CHP22	Bioenergy	SDG 7, SDG 9, SDG 12, SDG 13, SDG 15
15	CH	III/IV	IV/VI	U21CHP24	Hydrogen and Fuel Cell Technologies	SDG 7, SDG 9, SDG 13
16	CH	III/IV	IV/VI	U21CHP21	Energy Performance Assessment for Equipment and Utility Systems	SDG 7, SDG 9, SDG 12, SDG 13
17	CH	III/IV	IV/VI	U21CHP07	Fertilizer Technology	SDG 2, SDG 6, SDG 12, SDG 15
18	ME	II	V	U21MEP27	Renewable Energy Resources and Systems	SDG 7, 9, 12, 13
19	ME	III	V	U21MEP39	Bioenergy Conversion Technologies	SDG 7, 9, 12, 13
20	ME	IV	VII	U21MEP41	Energy Conservation in Industries	SDG 7, 9, 12, 13
21	ME	II	V	U21MEX04	Additive Manufacturing and 3D Printing	SDG 9, 12, 3
22	ME	III	V	U21MEX02	Intelligent Vehicle Systems	SDG 9, 11, 13
23	EE	3,4	5-7	U21EEP03	Microgrid	SDG 7, SDG 13
24	EE	3,4	5-7	U21EEP05	Power Quality	SDG 9
25	EE	3,4	5-7	U21EEP08	Smart Grid Technologies	SDG 7, SDG 9
26	EE	3,4	5-7	U21EEP12	HVDC Transmission	SDG 7, SDG 9
27	EE	3,4	5-7	U21EEP13	Advanced Electric Motors and Control	SDG 7, SDG 12
28	EE	3,4	5-7	U21EEP21	Electric Vehicles in Smart Grid	SDG 7, SDG 11, SDG 13

29	EE	3,4	5-7	U21EEP23	Energy Storage Systems	SDG 7, SDG 13
30	EE	3,4	5-7	U21EEP17	Battery Management Systems	SDG 7, SDG 13
31	EE	3,4	5-7	U21EEP24	IoT in EV Applications	SDG 9, SDG 11
32	BM	3,4	5-7	U21BMP20	ASSISTIVE TECHNOLOGY	SDG 3,SDG 10
33	BM	3,4	5-7	U21BMP13	Medical Device Regulations	SDG 3 , SDG 9
34	BM	3,4	5-7	U21BMP15	Medical Waste Management	SDG 3,SDG 12
35	BM	2	4	U21BMX02	Biometric Systems	SDG 9,SDG 16
36	CE	3,4	5-7	U21CEP09	Municipal Solid Waste Management	SDG 11,SDG 12
37	CE	3,4	5-7	U21CEP10	ENVIRONMENTAL IMPACT ANALYSIS	SDG 11,SDG 12,SDG 15
38	CE	3,4	5-7	U21CEP08	Urban Waste Water Engineering	SDG 6,SDG 11 ,SDG 14
39	CE	2	4	U21CEX01	Environmental & Social Impact Assessment	SDG 11,SDG 12,SDG 15
40	CE	2	4	U21CEX02	Integrated Water Resource Management	SDG 6,SDG 12
41	CE	3	5	U21CEX04	Waste Management	SDG 11,SDG 12

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Learn Beyond

SEMESTER I & II

		Category: MCC				
U25RMCC04	Environmental Governance and Sustainability (Common to AD, AM, BM, CB, CE, CH, CS, EC, EE, EV, IT, ME, MI, SC)	L	T	P	J	C
		2	0	0	0	2

QP PATTERN: A

COURSE OBJECTIVES:

- To provide basic concepts of ecosystem, biodiversity, atmospheric and hydrological processes
- To inculcate knowledge on the lithosphere, waste management practices, environmental laws and disaster management strategies
- To apply the principles of sustainable living and green technologies in alignment with the UN Sustainable Development Goals

COURSE OUTCOMES:

CO 1: Explain the role of biodiversity conservation and wildlife protection in addressing environmental issues **Understand**

CO 2: Apply pollution control methods, environmental laws, and water management practices for environmental protection **Apply**

CO 3: Implement sustainable waste management practices for efficient resource utilization **Apply**

CO 4: Explain the role of disaster management, governance, and IT tools in environmental and health sustainability **Understand**

CO 5: Employ sustainable practices and national environmental initiatives for sustainable development **Apply**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	2	1	-	-	-	3	2	-	1	-	1	-	-
CO 2	2	1	-	-	-	3	2	-	1	-	1	-	-
CO 3	2	1	-	-	-	3	2	-	1	-	1	-	-
CO 4	2	1	-	-	-	3	2	-	1	-	1	-	-
CO 5	3	1	-	-	-	3	2	-	1	-	1	-	-

SYLLABUS:

UNIT I: ENVIRONMENT AND BIODIVERSITY 6

Scope of Environmental Science - Ecology - Ecosystem - Classification, structure, productivity - Energy flow and nutrient cycles – Nitrogen cycle – Ecological succession - Biodiversity – Types and values of biodiversity – Biodiversity at Global, National and Local Levels - Bio-geographical Classification of India - India as a Mega-diversity Nation - Red Data Book - Hotspots of Indian Biodiversity - Endangered and endemic species - Conservation of biodiversity

Self - Learning & Case Studies - Species conservation projects in India - Species Reintroduction - National Biodiversity Action Plan 2015 - Role of International Union for Conservation of Nature (IUCN)

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UNIT II: ATMOSPHERE AND HYDROSPHERE 6

Atmosphere - Structure and composition - Earth's Albedo - Carbon cycle and oxygen cycle - Air Quality Standards - Air Pollution - Sources, effects and control measures - Indian Environmental Laws - Air Act 1981. Hydrosphere - Hydrosphere - Hydrological Cycle, Water Quality Parameters, Water Pollution - Sources, effects, and control measures - Water conservation - Rainwater harvesting, Dams, and watershed Management - Wastewater treatment, Ocean acidification, Blue economy, Water Act, 1974 and Environment Protection Act, 1986

Self - Learning & Case Studies - Clean Development Mechanism (CDM) - Greenhouse Gas Protocol - ISO 14064 - Jal Shakti Abhiyan - Implementation of CNG in NCT of Delhi - Taj Trapezium Case - Narmada River - Sardar Sarovar Project

UNIT III: LITHOSPHERE AND SOLID WASTE MANAGEMENT 6

Lithosphere - Structure of the lithosphere - Continental drift - Forest resources - Deforestation - Causes and effects - Agriculture - Effects of modern agriculture - Soil Pollution - Causes, effects and control measures. Solid Waste Management - Solid Waste - Sources, classification, and effects , Waste reduction strategies - Circular Economy and 5R Principles, Solid waste treatment, Disposal techniques, Refuse-Derived Fuel and Waste-to-Energy technologies,Biomedical, E-Waste and Hazardous waste management, Resource recovery - Environmental Standards and Waste Management Regulations (ISO 14001 and Waste Rules)

Self - Learning & Case Studies - Solid Waste Management rules, 2024 - Plastic Waste Management Rules (PWMR) - Degradation of Soil in Rajasthan - Indore's Waste Management System

UNIT IV: GLOBAL ISSUES, HUMAN WELFARE AND ROLE OF TECHNOLOGY 6

EIA- Concepts, stages - Land clearing projects - Environmental and social Impacts, Resettlement and Rehabilitation - Concepts and challenges - Disaster management - Floods, Landslides, Disaster management cycle and mitigation - Environmental Governance, Global Governance and Fundamental Human Rights - Importance. Human Population - Population growth, explosion and its challenges - Trends and variation among nations - Role of IT - Remote sensing, GIS and Google earth engine - Disease tracking and prediction using big data and AI (e.g., COVID-19 apps)

Self - Learning & Case Studies - Mission Amrit Sarovar - Beti Bachao Beti Padhao mission - Kerala Flood (2018) - Sterlite Copper Plant Case - Thoothukudi

UNIT V: SUSTAINABLE DEVELOPMENT AND GREEN PRACTICES 6

Sustainable Development - Concept, significance of sustainability - UN Sustainable Development Goals (UN SDGs) - Sustainability assessment - Carbon footprint, accounting, Carbon Neutrality - Net Zero Emissions - Carrying Capacity of the Earth - Carbon Sequestration and Carbon Capture - Blue Carbon and Green Carbon. Green Practices - Sustainable Agriculture - Green Energy - Biofuels, Green Hydrogen, Solar, wind and biomass Energy - Sustainable Transport - Electric Vehicles (EVs)

Self - Learning & Case Studies - National Solar Mission, Green India Mission - Ambikapur, Chhattisgarh - Zero Waste Model - Delhi Metro - Energy Efficiency and Sustainable Transport

CONTACT PERIODS:

Lecture: 30 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 30 Periods

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TEXTBOOKS:

1. E. Bharucha, "Environmental Studies for Undergraduate Courses", 2nd edition, Hyderabad, University Press (India) Pvt. Ltd, 2005
2. R. Rajagopalan, "Environmental Studies: From Crisis to Cure", 3rd edition, New Delhi, Oxford University Press, 2016
3. R. R. Hiremath, "Sustainable Development", 1st edition, New Delhi, Himalaya Publishing House, 2008

REFERENCES:

1. Anubha Kaushik and C.P. Kaushik, "Environmental Studies" 6th edition, New Age International Publishers, New Delhi, 2018
2. Benny Joseph, "Environmental Studies", 3rd edition, New Delhi, McGraw Hill Education, 2017
3. M. Anji Reddy, "Textbook of Environmental Science and Technology", 3rd edition,BS Publications, 2019
4. R. B. Singh, "Disaster Management", 1st edition, New Delhi, Rawat Publications, 2006
5. .V. Desai, "Environment and Sustainable Development" 1st edition, Mumbai, Himalaya Publishing House, 2009

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SEMESTER IV

U25CYX01	Organic Farming and Sustainable Agricultural Technologies	Category: OEC				
		L	T	P	J	C
		2	0	0	0	2

QP PATTERN: A

COURSE OBJECTIVES:

- To understand the basics and importance of organic farming and sustainable agriculture
- To familiarize soil health, organic nutrients, and eco - friendly crop protection methods
- To gain knowledge of sustainable farming, organic certification, and marketing organic product

COURSE OUTCOMES:

CO 1:	Apply the principles of organic and sustainable farming in suitable agricultural practices	**Apply**
CO 2:	Utilize suitable practices for maintaining soil health and fertility	**Apply**
CO 3:	Implement appropriate crop management and eco-friendly pest control methods	**Apply**
CO 4:	Utilize sustainable and modern technologies for agricultural production	**Apply**
CO 5:	Apply basic certification, marketing and traceability practices for organic products	**Apply**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	1	1	-	-	1	-	-	-	-	1	-	-
CO 2	3	1	1	-	-	1	-	-	-	-	1	-	-
CO 3	3	1	1	-	-	1	-	-	-	-	1	-	-
CO 4	3	2	1	-	-	1	-	-	-	-	1	-	-
CO 5	3	2	1	-	-	1	-	-	-	-	1	-	-

SYLLABUS:

UNIT I: INTRODUCTION TO ORGANIC FARMING **6**

Organic farming - Definition and scope - Conventional farming v/s organic farming - Effects of green revolution on soil, water and environment - Sustainable agriculture and its importance - Basic farming methods - Agroecology, natural farming and permaculture - Farm biodiversity - Regenerative agriculture and carbon farming

UNIT II: SOIL HEALTH AND MANAGEMENT **6**

Definition and composition of soil - Basic soil properties and soil testing - Soil factors affecting plant growth (light, temperature, water, humidity, pH and nutrients) - Carbon-to-Nitrogen (C:N) ratio and soil fertility - Organic manures and composting - Farmyard manure, green manuring and green leaf manuring - Vermicomposting and NADEP composting - Crop residue recycling and mulching

UNIT III: CROP MANAGEMENT AND PEST CONTROL **6**

Introduction to organic crop management - Land preparation and planting techniques - Nutrient management - Fertilizer recommendation - Blanket application - Major nutrient problems - Balance sheet approach - Crop rotation : need and benefits - Pest control, cultural, biological and mechanical methods - Integrated Pest Management (IPM)

UNIT IV: SUSTAINABLE AGRICULTURAL TECHNOLOGIES **6**

Water management - Drip and sprinkler irrigation - Rainwater harvesting - Protected cultivation - Hydroponics and vertical farming - Integrated farming and agroforestry - Renewable energy and farm waste recycling - Climate resilient agriculture - Precision agriculture using IoT sensors, drones and remote sensing

UNIT V: ORGANIC CERTIFICATION AND MARKETING **6**

Organic standards and certification - NPOP, PGS-India, NOP (USA) and EU regulations - Certification process: inspection, documentation and traceability - Jaivik Bharat logo and FSSAI labelling requirements - Marketing channels and supply chain - Farmer Producer Organizations (FPOs) - Government schemes: Paramparagat Krishi Vikas Yojana (PKVY) and National Mission on Natural Farming - Recent developments: Blockchain-based traceability and e-commerce platforms

CONTACT PERIODS:

Lecture: 30 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 30 Periods

TEXTBOOKS:

1. S.P. Palaniappan and K. Annadurai, “Organic Farming: Theory and Practice”, Scientific Publishers, Jodhpur, India.

2. A.K. Sharma, “A Handbook of Organic Farming”, Agrobios (India), Jodhpur, India

REFERENCES:

1. N. Lampkin, “Organic Farming”, Old Pond Publishing, UK, 1990

2. Stephen R. Gliessman, “Agroecology: The Ecology of Sustainable Food Systems”, CRC Press, 3rd Edition, 2014

3. A.K. Dahama, “Organic Farming for Sustainable Agriculture”, Agrobios (India), Jodhpur, India

SEMESTER IV

U25CYX02	Air Quality, Pollution and Control Techniques	Category: OEC				
		L	T	P	J	C
		2	0	0	0	2

QP PATTERN: A

COURSE OBJECTIVES:

- To introduce the fundamentals of air quality, pollution, sampling and monitoring methods
- To develop knowledge of industrial, indoor and vehicular pollution control techniques
- To familiarize the emerging and sustainable air pollution control technologies

COURSE OUTCOMES:

CO 1:	Apply air quality principles to common atmospheric pollution problems and their impacts	**Apply**
CO 2:	Utilize suitable techniques for air pollutant sampling, monitoring and quality assessment	**Apply**
CO 3:	Apply the appropriate technologies for controlling particulate and gaseous industrial emissions	**Apply**
CO 4:	Implement suitable strategies for controlling gaseous, indoor and vehicular air pollution	**Apply**
CO 5:	Employ sustainable technologies for emerging air pollution control and management	**Apply**

CO - PO MAPPING:

Particular	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO 1	3	2	1	1	-	-	-	-	-	-	1	-	-
CO 2	3	2	1	1	-	-	-	-	-	-	1	-	-
CO 3	3	2	1	1	-	-	-	-	-	-	1	-	-
CO 4	3	2	1	1	-	-	-	-	-	-	1	-	-
CO 5	3	2	1	1	-	-	-	-	-	-	1	-	-

SYLLABUS:

UNIT I: AIR QUALITY AND ATMOSPHERIC POLLUTION **6**

Atmosphere and composition - Air quality and air quality standards - Ambient and indoor air quality - Primary and secondary pollutants - Sources and characteristics of air pollutants - Effects of air pollution on human health, environment and climate - Photochemical smog - Acid rain - Greenhouse effect and global warming - Emerging air quality challenges

UNIT II: AIR SAMPLING, MONITORING AND QUALITY ASSESSMENT **6**

Principles and types of air sampling - Plume rise and types of behaviour - Ambient and stack sampling - Measurement of PM_{10} and $PM_{2.5}$ - Monitoring of major gaseous pollutants (SOx, NO_x, CO, O_3 and CO_2) - Basic instrumental methods, UV-Visible spectrophotometry and non-dispersive infrared (NDIR) techniques - Electrochemical and low-cost air-quality sensors - Portable and real time monitoring

UNIT III: INDUSTRIAL AIR POLLUTION CONTROL **6**

Industrial air pollution sources and emission characteristics - Selection of suitable control technology for industrial emissions - Principles of particulate and gaseous pollutant control - Gravity and centrifugal separators - Fabric filters - Electrostatic precipitators - Absorption and adsorption - Condensation - Thermal and catalytic oxidation

UNIT IV: GASEOUS, INDOOR AND VEHICULAR AIR POLLUTION **6**

Control of SO_x, NO_x and volatile organic compounds (VOCs) - Catalytic converters and catalytic combustion - Biofilters and biotrickling filters - Sources and effects of indoor air pollutants - Indoor air quality and sick building syndrome - Basic control and ventilation strategies - Automobile emissions from gasoline and diesel engines Formation and effects of CO, hydrocarbons and NO_x - Emission and control strategies

UNIT V: EMERGING AND SUSTAINABLE AIR POLLUTION CONTROL TECHNOLOGIES **6**

Alternative fuels, CNG, LPG, biofuels and hydrogen - Activated carbon and biochar for pollutant removal - Nanotechnology based air purification and nanofilters - Green and sustainable pollution control technologies - Carbon capture - Basic concepts and emerging air purification technologies - Integrated air pollution management and future trends

CONTACT PERIODS:

Lecture: 30 Periods **Tutorial:** - Periods **Practical:** - Periods **Project:** - Periods **Total:** 30 Periods

TEXTBOOKS:

1. Lawrence K,Wang, Norman C. Pareira, Yung Tse Hung, “Air Pollution Control Engineering”, 1st edition, Tokyo, Springer science media LLC,2004
2. Noel de Nevers, “Air Pollution Control Engineering”, 3rd edition, Long Grove, Illinois, Waveland Press, Inc., 2017

REFERENCES:

1. Y. Anjaneyulu, “Air Pollution and Control Technologies”, 1st edition, New Delhi, Allied Publishers (P) Ltd., 2002
2. Arthur C. Stern, “Air Pollution”,2nd edition, New York, Academic Press, 2006
3. S. Ganeshaguru, “Air Pollution Management”, 1st edition, ARS Publications, 2017
4. M. N. Rao and H. V. N. Rao, “Air Pollution”, 1st edition, New Delhi, Tata McGraw-Hill Publishing Company Limited, 2007
5. C. S. Rao, “Environmental Pollution Control Engineering”, 2nd edition, New Delhi, New Age International (P) Limited Publishers, 2006

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DEPARTMENT OF CHEMISTRY

SEMESTER IV

		Category: OEC				
U21CYX01	AIR POLLUTION AND CONTROL	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To acquire knowledge on atmosphere, classification of air pollutants and their effects on environment.
- To understand the principle of control methods of various air pollutants.
- To study automobile air pollutants emission and its control methods.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Describe the importance of atmosphere and the adverse effects of air pollutants (Understand)

CO2: Discuss the working principle of various types of control equipment for particulate contaminants (Understand)

CO3: Apply the control equipment for pollution prevention in industries (Apply)

CO4: Outline the sources, types and control methods of indoor air pollutants (Understand)

CO5: Explain the formation and control methods of automobile pollutants (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	1	2	3	-	-	-	-	1	-	-
CO2	3	2	2	-	1	2	3	-	-	-	-	1	-	-
CO3	3	2	2	-	1	2	3	-	-	-	-	1	-	-
CO4	3	2	2	-	1	2	3	-	-	-	-	1	-	-
CO5	3	2	2	-	1	2	3	-	-	-	-	1	-	-
Correlation levels:		1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION **7**

Structure and composition of atmosphere – Definition, Scope and Scales of air pollution – Sources and classification of air pollutants and their effect on human health, Vegetation, animals, property, aesthetic value and visibility – Ambient air quality (standards only)

UNIT II CONTROL OF PARTICULATE CONTAMINANTS **11**

Factors affecting selection of control equipment – Gas particle interaction – Working principle – Gravity separators, Centrifugal separators, Fabric filters, Particulate scrubbers, Electrostatic precipitators

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UNIT III CONTROL OF GASEOUS CONTAMINANTS 11

Factors affecting selection of control equipment – working principle – Absorption, adsorption, condensation, incineration, biofilters – Process control and monitoring (theory only)

UNIT IV INDOOR AIRQUALITY MANAGEMENT 10

Sources, types and control of indoor air pollutants, Sick building syndrome and building related illness – Sources and effects of noise pollution – Measurement standards – Control and preventive measures

UNIT V AIR POLLUTANTS FROM AUTOMOBILES 6

Air pollution due to gasoline driven and diesel driven engines – Formation of CO, HC, NO, effects, direct and indirect control methods

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung, "Air Pollution Control Engineering", 1st Edition,Tokyo, Springer science media LLC, 2004
2. Noel de Nevers, "Air Pollution Control Engineering",2nd Edition, Waveland press, Inc 2017

REFERENCES:

1. Anjaneyulu. Y, "Air Pollution and Control Technologies",1st Edition, Allied Publishers (P) Ltd., India 2002
2. Arthur C. Stern, "Air Pollution (Vol.I – Vol.VIII)", 2nd Edition, Academic Press,2006
3. S. Ganeshaguru, "Air Pollution Management",1st Edition, ARS Publications, 2017
4. M.N Rao and HVN Rao, "Air Pollution",2nd Edition, Tata Mcgraw Hill Publishing Company limited, 2007
5. C.S. Rao, "Environmental Pollution Control Engineering", 2nd Edition,New Age International (P) Limited Publishers, 2006

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course coordinator can choose any one / two components based on the nature of the course.

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DEPARTMENT OF CHEMISTRY
SEMESTER V

		Category: OEC				
U21CYX05	WASTE MANAGEMENT AND RESOURCE RECOVERY	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To provide fundamentals of solid waste collection, storage and management.
- To explain the solid waste processing, treatment technologies and integrated waste management.
- To summarize the principles of resource recovery and recycling.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain the impact of solid waste on environment and its management frameworks. (Understand)
CO2: Solve the solid waste collection, transportation and storage issues through innovative approaches. (Apply)
CO3: Find the design and operation of various solid waste management technologies.(Apply)
CO4: Apply the principles of resource recovery and recycling for the sustainable management of waste. (Apply)
CO5: Summarize the importance of sanitary landfill and integrated waste management to ensure environmental safety. (Understand)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	1	2	3	-	1	-	-	1		
CO2	3	2	2	-	1	2	3	-	1	-	-	1		
CO3	3	2	2	-	1	2	3	-	1	-	-	1		
CO4	3	2	2	-	1	2	3	-	1	-	-	1		
CO5	2	2	2	-	1	2	3	-	1	-	-	1		
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)				

SYLLABUS:

UNIT I FUNDAMENTALS OF SOLID WASTE MANAGEMENT 9

Introduction to solid waste – definition, types – municipal, industrial, biomedical, e-waste, hazardous – Sources and composition of solid wastes – Factors influencing waste generation and estimation – Impact of improper waste management on environment, health, and infrastructure – Sustainable waste management principles and hierarchy – Indian and international waste management regulations and frameworks (SWM Rules 2016, CPCB guidelines)

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UNIT II COLLECTION, TRANSPORTATION, AND STORAGE 9

Waste collection methods (door-to-door, community bin, curbside) and systems (primary, secondary, manual, mechanical, integration) – Design and operation of collection routes – Storage containers – types, sizing, and placement – Waste transportation – vehicles, logistics, and optimization – Transfer stations – design and function – Innovative waste collection technologies – smart bins, RFID tracking, IoT-enabled systems

UNIT III PROCESSING AND TREATMENT TECHNOLOGIES 9

Mechanical processing – shredding, screening, baling – Biological treatment – composting, vermicomposting, anaerobic digestion – design and operation – Thermal treatment – incineration, pyrolysis, gasification – working principles and emissions control – Chemical treatment – stabilization, neutralization, disinfection – Leachate and odour control mechanisms – Comparison of low- and high-cost tech treatment solutions

UNIT IV RESOURCE RECOVERY AND RECYCLING 9

Principles of 3R (Reduce, Reuse, Recycle) – Material recovery facilities (MRF) – types, design and function – Recovery of paper, plastic, glass, metals, and e-waste – Energy recovery from waste – RDF, biogas, and waste-to-energy plants – Life cycle assessment and economics of recycling systems – Material recovery technologies – optical sorting, eddy current – AI-based systems – Green products and circular economy concepts

UNIT V LANDFILLING AND INTEGRATED WASTE MANAGEMENT 9

Sanitary landfill – site selection, design, liner systems, gas and leachate collection – Post-closure care and environmental monitoring – Integrated Solid Waste Management (ISWM) – concept and planning – Public awareness and participation in waste management – Environmental impact assessment (EIA) for landfill projects – Case studies of successful waste management systems in India

Contact Periods:

Lecture:	45 hours	Tutorial:	- Hours	Practical:	- Hours	Project:	- Hours
						Total:	45 Hours

TEXT BOOKS:

1. G. Tchobanoglous, H. Theisen and S. A. Vigil, "Integrated Solid Waste Management: Engineering Principles and Management Issues", 1st Edition, McGraw Hill, 1993
2. M. Doble, K. Rollins, A. Kumar, "Green Chemistry and Engineering", 1st Edition, Academic Press, 2007
3. P. A. Vesilind, W. A. Worrell and D. R. Reinhart, "Solid Waste Engineering", 1st Edition, Cengage Learning, 2007
4. C. R. Rhyner, L. J. Schwartz, R. B. Wenger and M. G. Kohrell, "Waste Management and Resource Recovery", CRC Press, 1995

REFERENCES:

1. CPHEEO Manual on Municipal Solid Waste Management, Government of India.
2. Selected IS Codes, CPCB Guidelines and NGT Case Laws.

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EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components basedon the nature of the course.

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DEPARTMENT OF CHEMISTRY
SEMESTER VII

		Category: OEC				
U21CYX06	CHEMICAL ASPECTS OF FOOD ADULTERATION	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To provide chemical characteristics of food nutrients and impact of processing on major nutrients and vitamin content of food.
- To discuss about common adulterants in different foods and detection of food adulterants.
- To create awareness on food borne diseases, food poisoning and aspects of food safety.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain chemical characteristics of food nutrients and impact of processing on major nutrients. (Understand)

CO2: Describe various types of food adulterations and permissible food additives. (Understand)

CO3: Determine the common adulterants in food through different methods of analysis. (Apply)

CO4: Summarize the impact of microorganisms, contaminants and antibiotic residue leading to food poisoning. (Understand)

CO5: Explain the present regulations and procedures regarding food adulteration and consumer protection. (Understand)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	1	2	2	-	1	-	-	1		
CO2	2	2	2	-	1	2	2	-	1	-	-	1		
CO3	3	2	2	-	2	2	2	-	1	-	-	1		
CO4	2	2	2	-	1	2	2	-	1	-	-	1		
CO5	2	2	2	-	1	2	2	-	1	-	-	1		
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)						3: Substantial (High)					

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SYLLABUS:

UNIT I EFFECT OF PROCESSING ON MAJOR FOOD NUTRIENTS 9

Chemical constituents, characteristics – nutritional role and metabolic aspects of water, carbohydrates, proteins, fats, fibre, vitamins and minerals – Anti-nutritional factors of natural origin –Effect of processing on major nutrients and vitamin content of food – Natural pigments – chlorophylls, anthocyanin, carotenoids and curcumin – their structural composition and application in food industry

UNIT II FOOD ADULTERATION 9

Food adulteration – definition, types – Types of adulterants – intentional and incidental adulterants –poisonous substances, foreign matter, cheap substitutes, spoiled parts – Adulteration through food additives – intentional and incidental
Common food Additives – Organic acids, esters, alcohol, wood smoke – Legal aspects

UNIT III DETECTION OF COMMON FOOD ADULTERANTS 9

Common adulterants in different foods and theoretical aspects of detection of common food adulterants in – spices, grains, coffee, tea, oil/fats, food colours and Milk
Seminars on related/current food related issues (not from the syllabus)

UNIT V FOOD BORNE DISEASES AND FOOD POISONING 9

Food hazard – definition, types, general impact on Human Health – Food poisoning – types, prevention and control – Food borne diseases due to Bacterial, Viruses, Rickettsia, Mycotoxins, Parasites – Contaminants – Pesticide, insecticide, herbicide, fungicide, rodenticide – Antibiotic residue – toxic meal residue hormonal residue

UNIT V ASPECTS OF FOOD SAFETY 9

Concept of sanitation and hygienic production of food – Highlights of Food Safety and Standards Act 2006 (FSSA) – Food Safety and Standards Authority of India – Rules and Procedures of Local Authorities – Requirements and benefits of food grades and standard – BIS, AGMARK, ISI, FPO, CAC and FDA – Consumer's rights and responsibilities; COPRA 2019 – offenses and penalties, procedures to complain, compensation to victims.

Contact Periods:

Lecture:	45 Periods	Tutorial:	- Periods	Practical:	- Periods	Project:	- Periods
						Total:	45 Periods

TEXT BOOKS:

1. W. W. Harvey, "Foods and Their Adulteration", 1st Edition, Book on Demand Ltd, 2013
2. E. M. Bruce, "Detection of the Common Food Adulterants", Alpha Edition, 2021
3. J. P. Battershall, "Food Adulteration and Its Detection", 1st Edition, Nabu Press, 2011
4. R. J. Marshall, "Food Safety: A Practical and Case Study Approach", 1st Editio, Springer-Verlag New York Inc., 2007
5. E. S. West, W. R. Todd, H. S. Mason, J. vanBruggen, "Textbook of Biochemistry", 4th Edition, Oxford and IBH Publishing Co. Pvt. Ltd,

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DEPARTMENT OF CHEMISTRY
SEMESTER VII

		Category: OEC				
U21CYX06	CHEMICAL ASPECTS OF FOOD ADULTERATION	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To provide chemical characteristics of food nutrients and impact of processing on major nutrients and vitamin content of food.
- To discuss about common adulterants in different foods and detection of food adulterants.
- To create awareness on food borne diseases, food poisoning and aspects of food safety.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain chemical characteristics of food nutrients and impact of processing on major nutrients. (Understand)

CO2: Describe various types of food adulterations and permissible food additives. (Understand)

CO3: Determine the common adulterants in food through different methods of analysis. (Apply)

CO4: Summarize the impact of microorganisms, contaminants and antibiotic residue leading to food poisoning. (Understand)

CO5: Explain the present regulations and procedures regarding food adulteration and consumer protection. (Understand)

CO–PO MAPPING:

POs / Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO3	3	2	2	-	2	2	2	-	1	-	-	1		
CO4	2	2	2	-	1	2	2	-	1	-	-	1		
CO5	2	2	2	-	1	2	2	-	1	-	-	1		
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)						3: Substantial (High)					

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SYLLABUS:

UNIT I EFFECT OF PROCESSING ON MAJOR FOOD NUTRIENTS 9

Chemical constituents, characteristics – nutritional role and metabolic aspects of water, carbohydrates, proteins, fats, fibre, vitamins and minerals – Anti-nutritional factors of natural origin –Effect of processing on major nutrients and vitamin content of food – Natural pigments – chlorophylls, anthocyanin, carotenoids and curcumin – their structural composition and application in food industry

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Concept of sanitation and hygienic production of food – Highlights of Food Safety and Standards Act 2006 (FSSA) – Food Safety and Standards Authority of India – Rules and Procedures of Local Authorities – Requirements and benefits of food grades and standard – BIS, AGMARK, ISI, FPO, CAC and FDA – Consumer's rights and responsibilities; COPRA 2019 – offenses and penalties, procedures to complain, compensation to victims.

Contact Periods:

Lecture:	45 Periods	Tutorial:	- Periods	Practical:	- Periods	Project:	- Periods
						Total:	45 Periods

TEXT BOOKS:

1. W. W. Harvey, "Foods and Their Adulteration", 1st Edition, Book on Demand Ltd, 2013
2. E. M. Bruce, "Detection of the Common Food Adulterants", Alpha Edition, 2021
3. J. P. Battershall, "Food Adulteration and Its Detection", 1st Edition, Nabu Press, 2011
4. R. J. Marshall, "Food Safety: A Practical and Case Study Approach", 1st Editio, Springer-Verlag New York Inc., 2007
5. E. S. West, W. R. Todd, H. S. Mason, J. vanBruggen, "Textbook of Biochemistry", 4th Edition, Oxford and IBH Publishing Co. Pvt. Ltd,

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VERTICAL V

		Category: PEC				
U21CHP25	WATER CONSERVATION AND MANAGEMENT	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- The objective of the course is to provide the student with an understanding of the concepts and practices in Methodology of water conservation and water management
- To understand the various methods of water harvesting and Water resource development
- To understand the Different methods of water reuse and recycling and water management

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: To understand the Various methods of conservation of water and different models (Understand)

CO2: To understand the Different Methods of water Harvesting (Understand)

CO3: Plan and design Conservation and augmentation of water resources, water harvesting and groundwater recharge structures (Apply)

CO4: Students able to understand the different methodology of treatment of waste water (Understand)

CO5: Analysing the complex issues in water management (Analyze)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	2	2	-	-	-	-	-	-	1	1
CO2	2		-	-	2	-	-	-	-	-	-	-	1	1
CO3	2	2	-	-	2	2	1	2	-	-	-	-	1	1
CO4	2	-	-	-	2	-	-	-	-	-	-	-	1	1
CO5	3	-	-	-	2	2	-	-	-	-	-	-	1	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INTRODUCTION 9

Water and life– Management and conservation of water – Climate data– Conceptual models of runoff hydrograph– Dynamic models.

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UNIT II WATER HARVESTING 9

Storage structures – Percolation Tanks – Yield from catchments – Diversion of runoff – Ponds and reservoirs – Earth embankments

UNIT III WATER RESOURCES PLANNING 9

Statement of objectives – Data requirements – Project formulation – Environmental considerations in planning – Systems analysis – Pitfalls in project planning – Conservation and augmentation of water resources – Multipurpose projects – Functional requirements in multi-purpose project. Compatibility of multipurpose uses – Application of water resources systems engineering to practical problems

UNIT IV RECYLING AND REUSE 9

Recycling and reuse of water – Multiple uses of water – Reuse of water in agriculture – Low cost waste water treatment technologies – Economic and social dimensions – Packaged treatment units – Reverse osmosis and desalination in water reclamation

UNIT V WATER MANAGEMENT 9

Water quality management – Principles of water quality – Water quality classification – Water quality standards – Water quality indices – TMDL Concepts – Water quality models

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. R.K. Liniley and Franzini, "Water Resources Engineering" , 1st Edition, McGraw-Hill Book Co.,2005
2. Hall and Dracup, "Water Resources Systems Engineering", 1st Edition, McGraw Hill Book Co.,2007

REFERENCES:

1. George Tchobanoglous, Franklin Louis Burton, Metcalf & Eddy, H. David Stense, "Wastewater Engineering: Treatment and Reuse", 1st Edition, McGraw-Hill, 2002.
2. Suresh. R, "Soil and water conservation engineering" , 1st Edition, Standard publication, New Delhi, 2007
3. Chatterjee, S. N., Water Resources Conservation and Management, 1st Edition, Atlantic Publishers, 2008

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VERTICAL V

U21CHP27	WASTEWATER TREATMENT	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To know about the basics of biological water treatment methods
- To know about the applications of biological water treatment methods.
- To understand about various equipment used in water treatment methods.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understanding the Biochemical fundamentals and its operation (Understand)

CO2: Analysis of modeling of ideal suspended growth reactors (Analyze)

CO3: Design and Evaluation of suspended growth processes (Apply)

CO4: Analysis of modeling of Ideal attached growth reactors (Analyze)

CO5: Applications of Bioreactor for water treatment (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	1	1	-	1	2	1
CO2	3	1	1	-	-	-	-	1	1	1	-	1	2	1
CO3	3	1	1	-	-	-	-	1	1	1	-	1	2	1
CO4	3	1	1	-	-	-	-	1	1	1	-	1	2	1
CO5	3	1	1	1	-	-	-	-	1	1	-	1	2	1
Correlation levels:		1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION TO BIOCHEMICAL OPERATIONS **9**

Classification of Biochemical Operations – Fundamentals of Biochemical Operations

UNIT II TRADITIONAL BIOLOGICALTREATMENT **9**

Theory – Modeling of Ideal Suspended Growth Reactors: Modeling Suspended Growth Systems – Aerobic Growth of Heterotrophy in a Single Continuous Stirred Tank Reactor – Receiving Soluble Substrate – Multiple Microbial Activities in a Single and Continuous Stirred Tank Reactor

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UNIT III APPLICATION OF TRADITIONAL BIOLOGICAL TREATMENT **9**

Suspended Growth Reactors: Design and Evaluation of Suspended Growth Processes – Activated Sludge – Biological Nutrient Removal – Aerobic-digestion – Anaerobic Processes – Lagoons

UNIT IV BIOREACTORS FOR WATER TREATMENT **9**

Modeling of Ideal Attached Growth Reactors: Bio-film Modeling. Aerobic Growth of Biomass in Packed Towers – Aerobic Growth of Heterotrophs in Rotating Disc Reactors – Fluidized Bed Biological Reactors

UNIT V APPLICATIONS OF BIOREACTORS FOR WATER TREATMENT **9**

Attached Growth Reactors: Trickling Filter – Rotating Biological Contactor – Submerged Attached Growth Bioreactors

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Grady Jr, C. L., Daigger, G. T., Love, N. G., & Filipe, C. D. "Biological wastewater Treatment" . CRC press, 2018

2. Patwardhan, A. D., " Industrial wastewater treatment" . 1st Edition, PHI Learning Pvt. Ltd., 2017

REFERENCES:

1. Muga, H. E., & Mihelcic, J. R., " Sustainability of wastewater treatment technologies" , Vol 1, . Journal of Environmental Management, 2008

2. Cheremisino, N. P., " Handbook of water and wastewater treatment technologies" 1st Edition, .Butterworth – Heinemann, 2001

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	End Semester Examinations
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL V

U21CHP28	WASTE MANAGEMENT	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- Identify different types of waste and their environmental impacts.
- Implement effective waste collection, segregation, and recycling techniques.
- Develop sustainable waste management strategies that prioritize waste reduction and resource recovery.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain the basic principles and concepts of waste management, including the waste management hierarchy, waste reduction strategies, and the environmental and health (Apply)

CO2: Identify appropriate waste collection methods and segregation techniques, including source separation, recycling, and composting, in order to effectively manage different types of waste (Understand)

CO3: Evaluate different waste treatment and disposal methods such as landfilling, incineration, and composting, considering their environmental impacts, cost-effectiveness, and suitability for different types of waste (Apply)

CO4: Develop sustainable waste management strategies that prioritize waste minimization, recycling, resource recovery, and the use of renewable energy technologies, taking into account social, economic, and environmental factors (Analyze)

CO5: Identify and interpret waste management policies and regulations at the local, national, and international levels, understanding their implications for waste management practices and the responsibilities of different stakeholders (Understand)

CO-PO MAPPING:

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

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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SYLLABUS:

UNIT I INTRODUCTION TO WASTE MANAGEMENT 9

Definition and scope of waste management– Types and sources of waste – Environmental and health impacts of improper waste management – Waste management hierarchy: Reduce – Reuse– recycle and disposal – Waste management regulations and policies

UNIT II WASTE COLLECTION AND SEGREGATION 9

Waste collection systems: Municipal – Residential – commercial and industrial – Collection methods: Curbside pickup – Drop-off centers waste transfer stations – Waste segregation techniques: source separation – Recycling and composting – Waste collection equipment and technology – Community engagement and awareness program

UNIT III WASTE TREATMENT AND DISPOSAL 9

Waste treatment methods: Landfilling – Incineration and composting – Landfill design and operation: liner systems – Leachate collection and gas management – Incineration processes and emission control – Composting techniques and organic waste management – Hazardous waste treatment and disposal

UNIT IV Recycling and Resource Recovery 9

Recycling processes and technologies – Recycling of different materials: Paper – Plastics – Glass– metals – Challenges and opportunities in recycling.

UNIT V Sustainable Waste Management Strategies 9

Waste minimization and prevention strategies – Waste-to-energy technologies and renewable energy generation – Integrated waste management systems – E-waste management and recycling – International perspectives on waste management

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. John Pichtel, "Waste Management Practices: Municipal, Hazardous and Industrial" , 2nd Edition CRC Press, 2014

2. Tchobanoglous G., Theisen H., and Vigil S.A., "Integrated Solid Waste Management, Engineering Principles and Management" , 2nd Edition, McGraw-Hill, USA, 2014

REFERENCES:

1. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, "Environmental Engineering" , 1st Edition McGraw Hill Education, 2017

2. Thomas Christensen, "Solid Waste Technology & Management" ,Vol.1, John Wiley & sons, USA, 2011

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VERTICAL V

		Category: PEC				
U21CHP30	AIR POLLUTION, MONITORING AND CONTROL	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To provide an understanding of the basic concepts of air pollution and its adverse effects on human health and the environment.
- To introduce various air pollution control technologies and their principles.
- To enable students to design and implement air pollution control strategies

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify the sources and types of air pollutants and their effects on human health and the environment (Understand)

CO2: Analyze the principles and working mechanisms of various air pollution control technologies, such as scrubbers, electrostatic precipitators, and catalytic converters (Analyze)

CO3: Design and evaluate air quality monitoring programs using appropriate methods and instruments (Apply)

CO4: Explain the regulatory framework and policies for air pollution control at national and international levels (Understand)

CO5: Ability to exhibit the skill to develop membrane processes, adsorption process and inorganic separation process (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	3	-	-	1	-	-	-	-	3	3
CO2	2	1	2	2	3	-	-	1	-	-	-	-	3	3
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CO4	2	1	2	2	3	-	-	1	-	-	-	-	3	3
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Correlation levels:	1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)						

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SYLLABUS:

UNIT I Introduction 9

Introduction: Sources – Effects on – Ecosystems – Characterization of atmospheric pollutants – Air pollution episodes of environmental importance – Indoor Air Pollution – Sources – Effects

UNIT II Air Pollution Control Technologies 9

Principles and working mechanisms of various air pollution control technologies – Types of control devices (e.g.– Scrubbers – Electrostatic precipitators – Catalytic converters) – Evaluation of control technologies

UNIT III Air Quality Monitoring 9

Sampling and analysis of air pollutants – Air quality monitoring networks and methods – Data analysis and interpretation

UNIT IV Regulatory Framework and Policies 9

National and international regulations and policies for air pollution control – Emission standards and permits – Economic instruments for pollution control

UNIT V Air Pollution Control Strategies 9

Control strategies for different sources of air pollution (e.g., Industrial emissions – Transportation) – Cost-benefit analysis of control measures – Case studies of successful air pollution control programs

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Noel De Nevers, "Air Pollution Control Engineering", 2nd Edition, Waveland Pr Inc. 2010
2. Anjaneyulu Y, "Text book of Air Pollution and Control Technologies", 1st Edition, Allied Publishers, 2000

REFERENCES:

1. M. N. Rao and H V N Rao, "Air pollution", 2nd Edition, Tata Mc-GrawHill Publication. 2010
2. H. C. Perkins, "Air pollution", 1st Edition, Tata McGraw Hill Publication, 2006

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EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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VERTICAL IV

U21CHP23	RENEWABLE AND NON – RENEWABLE ENERGY RESOURCES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the global and Indian energy scenario, and the present and future energy demands.
- To familiarize with renewable and non-renewable energy sources and their classification, including their patterns of consumption and utilization.
- To introduce various non-conventional energy resources, including solar, geothermal, wind, bioenergy, tidal, and waste recycling plants, and their thermodynamics, working principles, performance, and limitations.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the current energy scenario in India and globally, and assess the present and future energy demands (Understand)

CO2: Compare the renewable and non-renewable energy sources, and evaluate the relative merits and demerits of each type (Understand)

CO3: Understand the thermodynamics of energy conversion processes for various energy sources, including coal, petroleum, and solar energy (Understand)

CO4: Understand the performance and limitations of various energy conversion systems, such as wind turbines, geothermal energy plants, and wave/tidal energy converters (Understand)

CO5: Evaluate the impact of energy utilization on the environment, and develop strategies for sustainable energy management and conservation (Evaluate)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	2	2	2	2	2	2	2	2	2
CO2	2	2	2	1	-	2	2	2	2	2	2	2	2	2
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CO5	2	2	2	1	-	2	2	2	2	2	2	2	2	2

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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SYLLABUS:

UNIT I INTRODUCTION 9

Energy Scenario: Indian and global, Present and future energy demands – Energy crisis– Classification of various energy sources – Renewable and non-renewable energy sources – Pattern of energy consumption.

UNIT II RENEWABLE ENERGY RESOURCES 9

Solid Fuels: Coal: Origin – Formation – Analysis – Classification – Washing and carbonization– Treatment of coal gas – Recovery of chemicals from coal tar – Coal gasification – Liquid fuel synthesis from coal – Carbonization of coal – Briquetting of fines. Liquid and Gaseous Fuels: Crude petroleum – Physical processing of crude petroleum – Fuels from petroleum – Storage and handling of liquid fuels – Natural and liquefied petroleum gases – Gas hydrates – Gasification of liquid fuels – Carbureted water gas – Non Renewable Energy Resources: Fossil fuels and their reserves nuclear energy – Types – Uses and effects Energy utilization and its effects on environment Energy crisis

UNIT III NON – RENEWABLE ENERGY RESOURCES 9

Introduction: Various non-conventional energy resources – Introduction – Availability – Classification – Relative merits and demerits. Solar Cells: Theory of solar cells. Solar cell materials – Solar cell array – Solar cell power plant – Limitations. Solar Thermal Energy: Solar radiation – Flat plate collectors and their materials – Applications and performance – Focusing of collectors and their materials – Applications and performance; Solar thermal power plants

UNIT IV GEOTHERMAL ENERGY AND WIND ENERGY 9

Geothermal Energy: Resources of geothermal energy – Thermodynamics of geothermal energy conversion – Electrical conversion – Non-electrical conversion – Environmental considerations. Wind power and its sources – Site selection – Criterion – Momentum theory – Classification of rotors – Concentrations and augments – Wind characteristics. Performance and Limitations of energy conversion systems.

UNIT V BIOENERGY AND TIDAL ENERGY 9

Bio-mass: Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability – Theory and working principle – Performance and limitations. Wave and Tidal Wave: Principle of working – Performance and limitations – Waste Recycling Plants

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

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TEXT BOOKS:

1. Raja, "Introduction to Non-Conventional Energy Resources" , 1st Edition, Scitech Publications, 2015
2. John Twidell and Tony Weir, "Renewal Energy Resources" , 3rd Edition, BSP Publications, 2015
3. M.V.R. Koteswara Rao, "Energy Resources: Conventional and Non-Conventional", 1st Edition, BSP Publications, 2006

REFERENCES:

1. Godfrey Boyle," Renewable Energy Power For A Sustainable Future", 3rd Edition, Oxford University Press, 2012
2. Rao, S. and Parulekar, B.B., "Energy Technology - Non-conventional Renewable and Conventional ", 3rd Edition, Khanna Publishers, 2000

EVALUATION PATTERN:

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VERTICAL IV

U21CHP20	ENERGY EFFICIENCY IN ELECTRICAL AND THERMAL UTILITIES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the fundamentals of energy efficiency in electrical and thermal utilities.
- To learn about energy-efficient technologies and their application in industrial systems.
- To analyze and assess energy use in different systems and identify opportunities for energy conservation.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the theory behind principles of electrical systems (Understand)

CO2: Understand energy-efficient technologies such as variable speed drives, energy-efficient motors, and automatic power factor controllers in industrial systems to optimize energy use and reduce waste (Understand)

CO3: Understand the energy conservation measures in thermal utilities such as boilers, furnaces, heat exchangers, and thermic fluid heaters (Understand)

CO4: Relate the technical and economic feasibility of cogeneration and waste heat recovery systems and their potential benefits for industrial applications (Understand)

CO5: Understand the waste heat recovery system and select appropriate commercial waste heat recovery devices to improve energy efficiency and reduce environmental impact (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	-	2	2	2	2	2	2	2	2	2
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Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

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SYLLABUS:

UNIT I ELECTRICAL SYSTEMS 9

Introduction to electric power supply systems – Electricity billing – Electrical load management and maximum demand control – Power factor improvement and benefits – Transformers – Distribution losses in industrial system – Assessment of transmission and distribution losses in power systems – Estimation of technical losses in distribution system – Demand side management – Harmonics – Analysis of electrical power systems

UNIT II ENERGY EFFICIENCY IN INDUSTRIAL SYSTEMS 9

Electric motors – Compressed air system – Fans and Blowers– Pumps and Pumping system– Cooling Tower: components – Types – losses – Efficiency – Factors affecting performance– control strategies– energy conservation opportunities – Energy Efficient Technologies in Electrical Systems – Maximum demand controllers – Automatic power factor controllers – Energy efficient motors – Soft starters with energy saver – Variable speed drives – Energy efficient transformers – Electronic ballast – Occupancy sensors – Energy efficient lighting controls – Energy saving potential of each technology

UNIT III ENERGY EFFICIENCY IN THERMAL UTILITIES 9

Thermal systems – Fuels and Combustion – Boilers– Furnaces – Heat exchangers and Thermic Fluid heaters - Efficiency computation and energy conservation measures; Steam distribution and usage – Steam traps – Condensate recovery – Flash steam utilization – Insulation & Refractories – Energy conservation in major utilities; Pumps – Fans – Blowers – Compressed air systems– Refrigeration and Air Conditioning systems – Cooling Towers – DG sets

UNIT IV COGENERATION 9

Need for Cogeneration – Principle – Types – Factors affecting cogeneration – Important technical parameters for cogeneration – Prime movers for cogeneration – Steam turbine efficiency – Cogeneration heat rate and efficiency assessment – Illustrative case – Trigeneration – Microturbine

UNIT V WASTE HEAT RECOVERY 9

Introduction – Types and applications – Benefits – Development of a waste heat recovery system – Commercial waste heat recovery devices.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Frank Kreith and D. Yogi Goswami, Energy Management and Conservation Handbook, 2nd Edition,CRC Press, 2008

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2. Zoebelein, Hans, "Guide books for National Certification Examination for Energy Manager", 4th Edition, Bureau of Energy Efficiency, 2015

REFERENCES:

1. S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 2nd Edition, 1991
2. Shobh Nath Singh, "Non-Conventional Energy Resources", Pearson Education India, 1st Edition 2015

EVALUATION PATTERN:

Continuous Internal Assessments					
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VERTICAL IV

		Category: PEC				
U21CHP21	ENERGY PERFORMANCE ASSESSMENT FOR EQUIPMENT & UTILITY SYSTEMS	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the various types of equipment used in industries such as boilers, furnaces, heat exchangers, electric motors, fans, blowers, pumps, compressors, and HVAC systems, and their performance testing methods and standards.
- To gain knowledge about the major areas and equipment used in thermal power stations, including coal handling plants, coal mills, boilers, turbines, and condensers, and the processes involved in iron and steel making and cement manufacturing.
- To understand the energy consumption patterns, material and energy balance, and performance monitoring of process equipment and utilities in industries such as the textile, pulp and paper, and fertilizer industries.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the fundamental principles and working mechanisms of various equipment used in industries such as boilers, furnaces, cogeneration systems, heat exchangers, electric motors, fans and blowers, pumps, compressors, and HVAC systems (Understand)

CO2: Understand the major areas/equipment involved in thermal power stations and steel, cement, pulp and paper, and fertilizer industries, along with their material and energy balance (Understand)

CO3: Understand the energy consumption patterns in different industries and how to monitor and optimize the energy consumption of production processes, process equipment, and utilities (Understand)

CO4: Understand the financial analysis of energy efficiency projects, including fixed and variable costs, interest charges, simple payback period, and discounted cashback methods (Understand)

CO5: Understand the energy performance of buildings and commercial establishments, including the determination of energy performance index and annual average hourly energy use, and the assessment of HVAC and lighting systems (Understand)

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CO-PO MAPPING:

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CO5	2	2	2	1	-	2	2	2	2	2	2	2	2	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION **9**

Boilers – Furnaces – Cogeneration systems – Heat Exchangers – Electric motors and variable speed drives – Fans and blowers – Pumps – Compressors – HVAC System – Purpose of the performance test – Testing methods – Scope – Standards – Factors.

UNIT II THERMAL POWER STATION AND STEEL INDUSTRY **9**

Thermal Power station: Major area/equipment – Coal handling plant – Coal Mills – Boilers – Draft system – Water pumping system – LP and HP heaters – Turbine – Condensers.

Steel Industry: Iron and Steel making routes – Primary steel process and secondary steel process – Case example.

UNIT III CEMENT INDUSTRY AND TEXTILE INDUSTRY **9**

Cement Industry: Cement manufacturing process – Material and Energy balance – Raw mill.

Textile Industry: Textile manufacturing process – Monitoring of energy consumption in production process – Performance monitoring of process equipment – Performance monitoring of utilities.

UNIT IV PULP– PAPER AND FERTILIZER INDUSTRY **9**

Pulp and Paper Industry: Pulp and paper manufacturing processes – Energy consumption pattern - Material and energy balance.

Fertilizer Industry: Fertilizer manufacturing processes – Energy flow – Material and Energy balance.

UNIT V FINANCIAL ANALYSIS, BUILDINGS AND COMMERCIAL ESTABLISHMENTS **9**

Financial Analysis: Fixed and variable costs – Interest charges – Simple payback period – Discounted cashback methods – Factors.

Buildings and Commercial Establishments: Determination of EPI and AAHEPI – Significance of

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building envelope – Assessment of HVAC systems – Performance assessment of lighting system.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. C.B.Smith, "Energy Management Principles", 2nd Edition, Pergamon Press, 2015.
2. Dale R. Patrick, S. Fardo, Ray E. Richardson, "Energy Conservation Guidebook", 3rd Edition, Fairmont Press, 2015.

REFERENCES:

2. Wayne C. Turner, "Energy Management Handbook", , 5th Edition,The Fairmont Press, Georgia, 2001.
3. Abbi Y. A., Jain Shashank, "Handbook on Energy Audit and Environment management", 5th Edition, TERI Press, New Delhi, 2006.

EVALUATION PATTERN:

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VERTICAL IV

		Category: PEC				
U21CHP22	BIOENERGY	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the classification, structure, properties, and functional roles of various biomolecules, including amino acids, carbohydrates, nucleotides, lipids, and fatty acids.
- To analyze and evaluate different techniques for biomass assessment, biochemical conversions, and thermochemical and chemical conversions, including biocatalysis by enzymes and pathways, fermentation and bioprocess engineering, and thermochemical conversion processes.
- To demonstrate an understanding of the physical and chemical characteristics of biofuels, including their Indian and international standard specifications, and assess their adaptation in various applications, including power generation, sustainable co-firing of biomass with coal, and biomass integrated gasification/combined cycles systems.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the fundamentals of biological systems necessary to grasp bioenergy concepts global bioenergy scenario and relate to bioenergy resources in India (Understand)

CO2: Understand the various biofuel types and its characteristics (Understand)

CO3: Understand the various types of bioenergy conversion systems in practice (Understand)

CO4: Understand the basic knowledge on algal culture, biomass harvest and biodiesel production (Understand)

CO5: Understand the national and international standards of biodiesel (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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SYLLABUS:

UNIT I INTRODUCTION TO BIOMOLECULES 9

Classification of amino acids – Carbohydrates and nucleotides; Structure and properties of carbohydrate polymers – Proteins and nucleic acids; Classification and utility of lipids and fatty acids; Functional roles of biomolecules – Energy carriers – Enzyme cofactors and biochemical regulation. Biosynthesis and Metabolism.

UNIT II BIOMASS 9

Biomass resources; classification and characteristics – Techniques for biomass assessment; Application of remote sensing in forest assessment – Biomass estimation – Biomass to biofuel; Source and classification of biofuels and their characteristics.

UNIT III BIOCHEMICAL CONVERSIONS 9

Biocatalysis by enzymes and pathways – Fermentation and bioprocess engineering – Chemical kinetics – Mathematical modelling of biochemical reactions – Bioreactor designs; Biodegradation and biodegradability of substrate; Anaerobic digestion – Bioconversion of lignocellulosic feedstock to sugars – Bioconversion of sugars and starches to fuels – Difference of the technologies of starch ethanol and cellulosic ethanol.

UNIT IV THERMOCHEMICAL AND CHEMICAL CONVERSIONS 9

Thermochemical Conversion: Direct combustion – Incineration – Pyrolysis – Gasification and liquefaction; Economics of thermochemical conversion – Biogasification: Biomethanation process– biogas digester types – Biogas utilisation; Waste to energy. Chemical Conversion: Hydrolysis & hydrogenation; Solvent extraction of hydrocarbons; Solvolysis of wood – Biocrude – Biodiesel production via chemical process – Catalytic distillation – Transesterification methods; Fischer-Tropsch diesel – Chemicals from biomass.

UNIT V BIOFUEL STANDARDS AND POWER GENERATION 9

Physical and chemical characteristics of biofuels – Biomass – Wood gas – Biomethane; Ethanol– biodisel – Wood oil; Bioblends – Indian and International standard specifications – Bioblends; Adaptation of biofuel in various applications – Biomass integrated gasification/combined cycles systems - Sustainable co-firing of biomass with coal; Biofuel economy – Case studies.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

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TEXT BOOKS:

1. David L. Nelson and Michael M. Cox, "Lehninger's Principles of Biochemistry" , 1st Edition, Macmillan Worth publisher, 2009.
2. Jeremy M Berg, LubertStryer, John L. Tymoczko, "Biochemistry", 6th Edition, W. H. Freeman, 2008.
4. D. Voet and J. Voet, "Voet and Voet's Biochemistry", 3rd Edition, John Wiley and Sons , 2005.

REFERENCES:

1. Bent Sorensen, "Renewable Energy", Academic Press, 3rd Edition,W. H. Freeman, 2004.
2. Zoebelein, Hans, "Dictionary of Renewable Resources" , 2nd Edition, Wiley-VCH,2009.

EVALUATION PATTERN:

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VERTICAL IV

		Category: PEC				
U21CHP24	HYDROGEN AND FUEL CELL TECHNOLOGIES	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the hydrogen fundamentals, storage and applications.
- To identify different areas of fuel cell technology.
- To find the applications of all the areas in day-to-day life.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the physical and chemical properties of hydrogen, its production and storage options, and safety and management concerns related to hydrogen applications (Understand)

CO2: Understand the different hydrogen storage methods and their applications (Understand)

CO3: Understand the principles, working, thermodynamics, and kinetics of different types of fuel cells, and evaluate their relative merits and demerits (Understand)

CO4: Compare different hydrogen storage technologies such as pressure cylinders, liquid hydrogen, metal hydrides, and carbon fibers, and analyze different reformer technologies for hydrogen production (Understand)

CO5: Understand fuel cycle analysis to fuel cell technology and compare it with other competing technologies such as battery-powered vehicles, SI engines fueled by natural gas and hydrogen, and hybrid electric vehicles (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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SYLLABUS:

UNIT I HYDROGEN FUNDAMENTALS 9

Hydrogen as a source of energy – Physical and chemical properties – Salient characteristics– Relevant issues and concerns.

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water– Hydrogen storage options – Compressed gas – Liquid hydrogen – Hydride– Chemical storage – Safety and management of hydrogen – Applications of hydrogen.

UNIT III FUEL CELLS - TYPES 9

Brief history – Principle – Working – Thermodynamics and kinetics of fuel cell process – Types of fuel cells; AFC – PAFC – SOFC – MCFC– DMFC – PEMFC – Relative merits and demerits– Performance evaluation of fuel cell – Comparison of battery Vs fuel cell.

UNIT IV FUEL CELLS – APPLICATION AND ECONOMICS 9

Fuel cell usage for domestic power systems – Large scale power generation – Automobile – Space applications – Economic and environmental analysis on usage of fuel cell – Future trends of fuel cells.

UNIT V FUELING AND FUEL CYCLE ANALYSIS 9

Hydrogen storage technology – Pressure cylinders – Liquid hydrogen – Metal hydrides – Carbon fibers – Reformer technology – Steam reforming – Partial oxidation – Auto thermal reforming – CO removal – Fuel cell technology based on removal like bio-mass – Introduction to fuel cycle analysis – Application to fuel cell and other competing technologies like battery powered vehicles – SI engine fueled by natural gas and hydrogen and hybrid electric vehicle.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Supramaniam Srinivasan, "Fuel Cells: From fundamentals to applications",1st Edition, Springer, 2010
2. Viswanathan B, "Fuel Cells – Principles and Applications", 1st Edition, Universities press, 2007

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REFERENCES:

1. Bent Sorensen (Sorensen), "Hydrogen and Fuel Cells: Emerging Technologies and Applications", 5th Edition, Elsevier Academic Press, UK, 2011
2. Kordesch, K and G.Simader, "Fuel Cell and Their Applications" , 1st Edition, Wiley-Vch, Germany, 1996
3. Hart, A.B and G.J.Womack, "Fuel Cells: Theory and Application", 2nd Edition, Prentice Hall, NewYork Ltd., London, 1989

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

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KPR Institute of Engineering Centre for Academic Courses Coimbatore

KPRIET
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VERTICAL II

U21CHP07	FERTILIZER TECHNOLOGY	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- Learn the fertilizer manufacturing including new or modified fertilizer products
- Understand the practical methods of production in a chemical factory
- Learn about the importance of nutrients

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Understand the classification of fertilizers and its application (Understand)

CO2: Understand process and properties of synthesis condition of different fertilizers (Understand)

CO3: Identify the manufacturing of potassium chloride and Sulphate (Understand)

CO4: Analyze the manufacturing of NPK and Ammonium Sulphate Phosphate (Analyse)

CO5: Analyze the Biofertilizer and preparation of Biofertilizer (Analyse)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	1	-	-	-	-	-	-	-	1	1
CO2	3	2	-	-	1	-	-	-	-	-	-	-	1	1
CO3	3	2	-	-	1	-	-	-	-	-	-	-	1	1
CO4	3	2	-	-	1	-	-	-	-	-	-	-	1	1
CO5	3	2	-	-	1	-	-	-	-	-	-	-	1	1
Correlation levels:			1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)				

SYLLABUS:

UNIT I OVERVIEW OF FERTILIZER 9

Synthetic fertilizers – Classification of fertilizers – Role of essential Elements in plant Growth – Application of fertilizers considering Nutrient – Development of fertilizer industry – Fertilizer production and consumption in India – Nutrient contents of fertilizers

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UNIT II NITROGENOUS FERTILIZERS 9

Physical & Chemical properties – Synthesis gas by Catalytic partial oxidation – Kellogg process and Haldor Topsoe process – Storage and Transportation of Ammonia – Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process

UNIT III POTASSIUM FERTILIZERS 9

Physical, Chemical properties and uses of Potassium Chloride – Potassium nitrate – Potassium sulphate – Manufacturing of potassium chloride from sylvinite – Preparation of Potassium nitrate – Potassium sulphate

UNIT IV MISCELLANEOUS FERTILIZER 9

Manufacturing of NPK – Ammonium Sulphate Phosphate (ASP) – Calcium Ammonium Nitrate (CAN)

UNIT V BIO FERTILIZERS 9

Biofertilizers – Types of Biofertilizers – Nitrogen fixing Biofertilizers – Phosphate-solubilizing Biofertilizers – Preparation of a Biofertilizers

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Ranjan Kumar Basak., "Fertilizer A textbook", 5th Edition, Kalyani Publishers, Chennai, 2016
2. Gustafson A.F., "Handbook of Fertlizers-Their sources, Make-up, Effects, and Use", 8th Edition, Read Books Ltd, New Delhi, 2010

REFERENCES:

1. Austin G. T, "Shreve's Chemical Process Industries", 5th Edition, McGraw Hill Publications, New Delhi, 2017
2. Pandey & Shukla, "Chemical Technology", 2nd Edition, Vani Books Company, India, 1997
3. Subba Rao N S, "Bio fertilizers in Agriculture", 6th Edition, Oxford & IBH Publishing Company, New Delhi, 1998
4. https://nptel.ac.in/courses/103107086
5. https://iopscience.iop.org/article/10.1088/1755-1315/250/1/012048/pdf

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EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
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40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

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PROFESSIONAL ELECTIVE

U21MEP27	RENEWABLE ENERGY RESOURCES AND SYSTEMS	Category: PEC				
		L	T	P	L	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To emphasize the importance of using various renewable energy systems in the present energy scenario
- To impart the knowledge on the working of solar energy, wind energy and small hydro systems
- To inculcate the knowledge on ocean energy and biomass systems

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain the energy scenario and the importance of renewable energy systems (Understand)

CO2: Illustrate the working of solar thermal and photovoltaic systems (Understand)

CO3: Describe the components of wind energy and small hydro energy systems (Understand)

CO4: Explain the technology to generate energy through ocean energy conversion (Understand)

CO5: Describe the methods of generating energy from the biomass (Understand)

CO–PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO3	2	1	-	-	-	-	2	-	-	-	-	-	1	-
CO4	2	1	-	-	-	-	1	-	-	-	-	1	1	-
CO5	2	1	-	-	-	-	1	-	-	-	-	1	1	-

SYLLABUS:

UNIT I INTRODCUTION TO RENEWABLE ENERGY RESOURCES 9

Energy chain and common forms of usable energy – World energy status – Energy scenario in India – Classification of energy resources; conventional energy resources – Availability and their limitations; Renewable energy resources – Classification – Needs – Advantages and limitations – Applications

UNIT II SOLAR ENERGY SYSTEMS 9

Introduction to solar energy – Energy from Sun – Spectral distribution of solar radiation – Instruments for measurement of solar radiation; Solar thermal collectors – Flat plate collectors – Evacuated tubes – Concentrators – Applications – Solar photovoltaic systems – Physics of solar cells – Characteristics of cells and module – Performance parameters – Balance of system (BoS) – Types of photovoltaic systems – Applications

UNIT III WIND ENERGY AND SMALL HYDRO POWER SYSTEMS 9

Principles of wind power – Wind turbine operation – Site characteristics – Selection of components – Types of wind turbines – Power regulation – Various methods of control – Design principles of wind turbine blades – Wind farms – Off shore wind farms – Solar wind hybrid energy systems – Introduction small hydro power systems – Types – System components – Discharge curve and estimation of power potential – Turbines for small hydro power plants

UNIT IV OCEAN ENERGY SYSTEMS 9

Tidal energy – Principle of tidal power – Components of tidal power plant (TPP) – Classification of tidal power plants – Advantages and limitations of TPP – Ocean Thermal Energy Conversion (OTEC): principle of OTEC system – Methods of OTEC power generation – Open cycle (Claude cycle) – Closed cycle (Anderson cycle) and hybrid cycle (block diagram description of OTEC); site – Selection criteria – Bio – Fouling – Advantages and limitations of OTEC

UNIT V ENERGY FROM BIOMASS 9

Biomass fuels – Concepts and systems – Biomass production – Energy plantations – Biomass resources and processing – Environmental factors; Pyrolysis – Fixed bed and fast pyrolysis – Gasification and liquefaction – Types of gasifiers; Bioconversion: biogas – Fermentation and wet processes; Biofuels: Manufacturing methods and properties

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Rai G D, “Non-Conventional Sources of Energy”, 6th edition, Khanna Publishers,2017
2. D.P.Kothari, K.C.Singal, Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd edition, Prentice Hall of India,2011

REFERENCES:

1. Fang Lin Luo, Hong Ye, “Renewable Energy Systems: Advanced Conversion Technologies and Applications”,1st edition, CRC Press,2012
2. John.A.Duffie, William A.Beckman, “Solar Engineering of Thermal Processes”, 4th edition, John Wiley & Sons,2013
3. Bent Sorensen, "Renewable Energy", 5th edition, Academic Press,2017

EVALUATION PATTERN:

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PROFESSIONAL ELECTIVE

U21MEP39	BIOENERGY CONVERSION TECHNOLOGIES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To introduce the energy conversion technologies related to biomass
- To familiarize the properties of biomass and its energy products
- To analyze the feasibility of power production from biomass sources

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Describe the properties of biomass and the energy conversion process. (Understand)

CO2: Compare the characteristics of products obtained from biomass pyrolysis (Understand)

CO3: Interpret the fundamentals of biomass gasification and gasifier design. (Understand)

CO4: Assess the potential of electrical power production from biomass (Understand)

CO5: Describe national and international standards of biofuels. (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO3	2	1	-	-	-	-	2	-	-	-	-	-	1	-
CO4	2	1	-	-	-	-	2	-	-	-	-	-	1	-
CO5	2	1	-	-	-	-	2	-	-	-	-	-	1	-

SYLLABUS:

UNIT I INTRODUCTION TO BIOMOLECULES **9**

Classification of amino acids – Carbohydrates and nucleotides – Structure and properties of carbohydrate polymers – Proteins and nucleic acids – Classification and utility of lipids and fatty acids – Functional roles of biomolecules – Energy carriers – Enzyme cofactors and biochemical regulation – Biosynthesis and Metabolism

UNIT II BIOMASS **9**

Biomass as energy source – Sources – Biomass conversion processes – Biological – Thermal – Chemical – Hybrid conversions – Application of biomass conversion products – Biomass properties for conversion process – Physical properties : Particle size, distribution, heat capacity and thermal conductivity – Thermal properties : Proximate, Ultimate and heating value analysis – Biomass pretreatment processes – Biodiesel and bioethanol : Sources and extraction methods

UNIT III TORREFACTION AND LIQUEFACTION **9**

Torre faction – products obtained – properties of terrified biomass – Physical and chemical – composition changes – Torre faction as pretreatment process – Pyrolysis – Types – Effects of process parameters – Product characterization techniques – Oxidation stability – Bio-oil upgradation – Applications – Liquefaction – Direct and indirect methods – Advanced liquefaction techniques

UNIT IV BIOMASS GASIFICATION 9

Biomass gasification – Chemistry – Types of gasifiers – Gasifier design: TDR, throughput, A/F ratio and equivalence ratio calculations – Advanced gasification – Fluidized bed gasifier – Component design – Cold fluidization tests – Electrical power production – Biomass combustion – Types of combustors – Co-combustion and Co-firing – Applications – Eutectic point of biomass ash

UNIT V BIOFUELS STANDARDS AND POWER GENERATION 9

Physical and chemical characteristics of biofuels – Biomass – Wood gas – Biomethane – Ethanol – Biodiesel – Wood oil – Bioblends – Indian and International standard specifications – Bioblends – Adaptation of biofuel in various applications – Biomass integrated gasification/combined cycles systems – Sustainable co-firing of biomass with coal – Biofuel economy.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Sergio C. Capareda, “Introduction to Biomass Energy Conversions”, 1st edition, CRC Press,2013
2. Prabir Basu, “Biomass Gasification, Pyrolysis and Torre faction”, 2nd edition, Academic Press,2013

REFERENCES:

1. Erik Dahlquist, “Biomass as Energy Source: Resources, systems and applications”, 2nd edition, CRC Press,2012
2. Anju Dahiya, “Bioenergy: Biomass to Biofuels”, 3rd edition, Academic press,2014
3. D.P.Kothari, K.C Singal and Rakesh Ranjan “Renewable Energy Sources And Emerging Technologies”, 2nd edition, Prentice Hall of India,2011

EVALUATION PATTERN:

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<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
<tr><td colspan="4" rowspan="2">Total</td><td>40</td><td>60</td></tr>
<tr><td colspan="2">100</td></tr>
</table>

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

PROFESSIONAL ELECTIVE

U21MEP41	ENERGY CONSERVATION IN INDUSTRIES	Category: PEC			
		L	T	P	C
		3	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the types of fuels used in Industries and their characteristics
- To know the techniques adopted for performance evaluation of thermal utilities
- To learn the working principle employed in VCRS and VAM systems

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Estimate the stoichiometric air for fuel and suggest measures for efficient combustion (Apply)

CO2: Outline the reasons for underperformance of thermal utilities and suitable remedial measures. (Understand)

CO3: Analyze the factors affecting COP of a VCR and VAR system (Analyze)

CO4: Use appropriate methods to determine the performance of induction motors and transformers.(Apply)

CO5: Assess energy conservation avenues of thermal and electrical utilities (Apply)

CO–PO MAPPING:

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

SYLLABUS:

UNIT I BOILERS **9**

Types – Performances evaluation via direct and indirect method – Energy conservation avenues – Properties of steam – Assessment of steam distribution losses – Steam trapping – Condensate and flash steam recovery system – Opportunities for energy saving in steam consumption systems

UNIT II FURNACES AND THERMIC FLUID HEATERS **9**

Furnaces and Thermic Fluid Heaters: Types – Performances evaluation via direct and indirect method – Energy conservation avenues – Insulation and refractory: types and application

UNIT III HVAC AND WASTE HEAT RECOVERY **9**

VCRS – Performance assessment – Energy savings opportunities – VAM: working, types, benefits, comparison with vapor compression system – WHR systems: Classification – Benefits – Commercial waste heat recovery devices: recuperator, regenerator, heat pipe, heat exchangers (Plate, Shell & Tube), heat pumps, thermo compressor – CHP – Poly generation

UNIT IV ELECTRICAL SYSTEMS AND INDUCTION MOTORS 9

Electricity billing – Demand side management – Power factor improvement transformer losses – Harmonics induction Motors: Types – Losses – Performance assessment adopting direct and indirect method – Factors affecting motor performance – Energy efficient motors

UNIT V ENERGY CONSERVATION IN ELECTRICAL UTILITIES 9

Performance assessment and energy conservation avenues in: Fans – Blowers – Pumps – Air compressors – Illumination systems – Cooling towers

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Total: 45 Periods

TEXT BOOKS:

1. Alwyn Clarenece asts, A., Pon Vengatesh, R., “Electrical energy generation utilisation and conservation", 1st edition, Bennett Coleman,2007
2. Rao, Sunil S., "Utilization generation and conservation of electrical energy”, 1st edition, Khanna Publisher,2005

REFERENCES:

1. K. Nagabhushan Raju, “Industrial Energy Conservation Techniques: (concepts, Applications and Case Studies)”, 1st edition, Atlantic Publishers,2007
2. Albert Thumann and Paul Mehta D, “Handbook of Energy Engineering”, 7th edition, The Fairmont Press,2013
3. Steve Doty, Wayne Turner C, “Energy Management Handbook”, 7th edition, The Fairmont Press, 2009

EVALUATION PATTERN:

Continuous Internal Assessments					End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)		Total Internal Assessments	
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

U21MEX04 – Additive Manufacturing and 3D Printing

Unit I – Introduction: Need, development, principles, process chain, classification, rapid prototyping/tooling/manufacturing, applications and benefits.

Unit II – Design for Additive Manufacturing: CAD preparation; part orientation; support structures; slicing; tool paths; DFAM objectives; quality improvement; customized medical fabrication.

Unit III – Photopolymerization and Powder Bed Fusion: SLA, photopolymer materials, SLS, powder-fusion mechanisms, process parameters and electron-beam melting.

Unit IV – Extrusion and Sheet Lamination: FDM; materials, applications and limitations; bio-extrusion; LOM; adhesive/thermal bonding.

Unit V – Printing and Beam Deposition: 3D printing and droplet formation; bioplotter; LENS beam-deposition process, materials, parameters and applications.

U21MEX02 – Intelligent Vehicle Systems

Unit I – Smart Mobility Technologies: Foundational technologies; PNT/GIS; wireless communication; mobile computing; blockchain; IoT; AI; robotics; electrification.

Unit II – Smart Mobility Enablers: Intelligent infrastructure; connected and automated mobility; e-mobility; micro-mobility; active/soft/zero-impact mobility; inclusive mobility; context-awareness systems.

Unit III – Smart Mobility Disruptors: Shared mobility; Mobility-as-a-Service; Mobility-on-Demand; integrated mobility; last-mile delivery; Vehicle-as-a-Service; passenger economy.

Unit IV – Autonomous Intelligent Vehicles: Road/vehicle detection and tracking; localization/navigation; DGPS/IMU; driver assistance and intelligent speed adaptation.

Unit V – Advanced Vehicle Motion Control: Cruise control; longitudinal/lateral/steering control; lane-change assistance; pedestrian protection; parking assist; post-crash support.

U21EEP03	MICROGRID	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

To present the architecture and operational characteristics of microgrids.

To introduce control strategies and power electronic interface techniques used in microgrid operation.

To emphasize the principles of communication, protection, and energy management in microgrids.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze microgrid architecture and operational characteristics. (Analyze)

CO2: Apply power electronic interfaces in microgrid applications. (Apply)

CO3: Implement converter and inverter control techniques in microgrid systems. (Apply)

CO4: Investigate communication protocols used in microgrid operation. (Analyze)

CO5: Examine microgrid operation and protection under grid-connected and islanded modes. (Analyze)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	-	-	-	-	-	-	1	-	2
CO2	3	2	1	-	1	-	-	-	-	-	-	1	-	2
CO3	3	2	1	-	2	-	-	-	-	-	-	1	-	2
CO4	3	3	2	1	2	-	-	-	-	-	-	1	-	2
CO5	3	3	2	1	2	-	-	-	-	-	-	1	-	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I MICROGRID STRUCTURE **9**

Typical structure and configuration – Significance – Sources – Types: AC, DC and hybrid microgrid – Technical implications and social fall out – Market models and business cases for microgrid

UNIT II MICROGRID SOURCES AND POWER ELECTRONIC INTERFACES **9**

Review of microgrid sources – Basic characteristics and selection – Power electronics interface – Design for microgrid – DC and AC sources – Protection and co-ordination – Power quality issues and solutions

UNIT III CONTROL AND DESIGN OF POWER ELECTRONIC INTERFACES 9

Microgrid control architecture – Control strategies: Centralized and decentralized control – Multi-agent system-based control – Power relations and power control – Control of DC-DC converters and inverter – Microgrid challenges – Energy management in microgrid

UNIT IV COMMUNICATION INFRASTRUCTURE 9

Requirement of communication system in microgrid – Communication protocols and standards – Selection of communication protocols for microgrid – Event triggered system and Time triggered system – Unicast and multicast communication – Impact of time latencies on operation

UNIT V OPERATION AND PROTECTION OF MICROGRID 9

Grid connected and islanding mode of operation – Challenges for microgrid protection – Adaptive protection – Fault current source for effective protection in islanded operation – Fault current limitation in microgrids

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Nikos Hatziargyriou, “Microgrids: Architectures and Control”, Wiley-IEEE Press, 2013
2. Sharkh S.M., Abu-Sara M.A., Orfanoudakis G.I. and Hussain B., “Power Electronic Converters for Microgrids”, Wiley – IEEE Press, 2014

REFERENCES:

1. Naser Mahdavi Tabatabaei, Ersan Kabalci, Nicu Bizon, “Microgrid Architectures, Control and Protection Method”, Springer, 2020
2. Magdi S. Mahmoud, “Microgrid Advanced Control Methods and Renewable Energy System Integration”, Elsevier, 2017
3. Li Fusheng, Li Ruisheng, Zhou Fengquan, “Microgrid Technology and Engineering Application”, Elsevier, 2016

EVALUATION PATTERN:

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U21EEP05	POWER QUALITY	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

To develop a comprehensive understanding of power quality disturbances and their underlying causes in electrical power systems.

To present advanced mitigation techniques for improving and maintaining power quality in modern power networks.

To emphasize the principles and methodologies of power quality monitoring and measurement in electrical systems.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze power quality disturbances and standards. (Analyze)

CO2: Model mitigation techniques for voltage sags and interruptions. (Apply)

CO3: Apply protection methods against over voltages. (Apply)

CO4: Investigate harmonic effects in power systems. (Analyze)

CO5: Implement power quality measurement and monitoring techniques. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	-	-	-	-	-	-	1	-	2
CO2	2	2	1	1	1	-	-	-	-	-	-	1	-	2
CO3	2	1	1	1	1	-	-	-	-	-	-	1	-	2
CO4	2	1	-	-	-	-	-	-	-	-	-	1	-	2
CO5	2	1	1	1	1	-	-	-	-	-	-	1	-	2
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

SYLLABUS:

UNIT I POWER QUALITY AND ITS STANDARDS 9

General classes of power quality problems: Concepts of transients, short duration and long duration voltage variations, voltage imbalance, waveform distortions, frequency variations and voltage fluctuations – Power quality standards: IEEE, IEC, CBEMA and ITI curves

UNIT II VOLTAGE SAGS AND INTERRUPTIONS 9

Sources of sag and interruptions – Estimating voltage sag performance – Analysis and calculation of various fault conditions – Mitigation of voltage sags – Active series compensators – Static transfer and fast transfer switches – Voltage sag study using simulation

UNIT III OVER VOLTAGES AND ITS MITIGATIONS 9

Sources of over voltages – Capacitor switching – Lightning – Mitigation of voltage swells – Surge arresters – Power conditioners – Lightning protection – Line arresters – Protection of transformers and cables – Ferro-resonance – Switching transients – Voltage swell study using simulation

UNIT IV HARMONICS AND ITS EFFECTS 9

Harmonic distortion – Voltage and current distortions – Power system quantities under non - sinusoidal conditions – Harmonic indices – Harmonic sources from commercial and industrial loads – System response characteristics – Effect of harmonics – Devices for controlling harmonic distortion

UNIT V POWER QUALITY MEASURING INSTRUMENTS 9

Flicker meters, disturbance analyzer, spectrum and harmonic analyzer, data chart recorders and smart power quality monitors – Basics of computer analysis tools – Intelligent system for power quality monitoring – Case study

Contact Periods:

Lecture: 45 Periods Tutorial: - Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, “Electrical Power Systems Quality”, 3rd edition, Tata McGraw Hill, 2012
2. Bhim Singh, Ambrish Chandra and Kamal Al-Haddad, “Power Quality Problems and Mitigations Techniques”, 2nd edition, John Wiley, 2015

REFERENCES:

1. Math H.J.Bollen, “Understanding Power Quality Problems: Voltage Sags and Interruptions”, IEEE Press, 2011
2. Arrillaga.J., Watson.N.R. and Chen.S., “Power System Quality Assessment”, 3rd edition, John Wiley and Sons Ltd., 2011
3. Beaty H. Wayne, McGranaghan and Mark, “Electrical Power Systems Quality”, 3rd edition, 2012
4. https://archive.nptel.ac.in/courses/108/102/108102179/

EVALUATION PATTERN:

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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

U21EEP08	SMART GRID TECHNOLOGIES	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To develop the ability to analyze smart grid architecture and its key components.
- To build competence in applying computational and optimization techniques in smart grid analysis.
- To foster analytical skills for evaluating renewable energy integration and smart grid operation.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze smart grid architecture and challenges. (Analyze)

CO2: Investigate communication and measurement technologies. (Analyze)

CO3: Apply optimization techniques for smart grid operation. (Apply)

CO4: Examine power electronic converters and energy storage systems. (Analyze)

CO5: Model techniques to integrate renewable energy in smart grids. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	-	-	-	-	-	-	-	1	-	2
CO2	3	3	2	1	-	-	-	-	-	-	-	1	-	2
CO3	3	3	2	1	2	-	-	-	-	-	-	1	-	2
CO4	3	3	2	1	-	-	-	-	-	-	-	1	-	2
CO5	3	3	2	1	-	-	-	-	-	-	-	1	-	2
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)								3: Substantial (High)			

SYLLABUS:

UNIT I SMART POWER GRID **9**

Grid challenges – Evolution – Characteristics and benefits of smart grid – Vision and roadmap for India – Examples of smart grid projects in India, US and Europe effort – Comparison of microgrid and smart grid – Cyber controlled smart power grids - Consumer versus prosumer

UNIT II COMMUNICATION AND MEASUREMENT **9**

Functions of smart grid components – Communication and measurement – Monitoring, PMU and smart meters – Demand side integration – Synchrophasor measurement – IEEE Standards, Multi agent systems technology

UNIT III COMPUTATIONAL TOOLS **9**

Decision support tools – Optimization techniques – Heuristic optimization – Evolutionary computational techniques – Adaptive Dynamic Programming (ADP) techniques – Load flow for smart grid design – Hybridizing optimization techniques

UNIT IV POWER ELECTRONICS AND ENERGY STORAGE SYSTEMS **9**

Current source and voltage source converters – Shunt and series compensators with energy storage – Energy storage technologies: Batteries, flow battery, fuel cell, flywheels, superconducting magnetic energy storage systems, super capacitors and energy storage for wind power

UNIT V CASE STUDIES AND TESTBEDS **9**

Demonstration projects – Advanced metering – Microgrid with renewable energy – ADP for optimal network reconfiguration in distribution automation – Case study of renewable energy integration – Testbeds and benchmark systems – Challenges and benefits of smart transmission

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Salman K. Salman, “Introduction to the Smart Grid Concepts, Technologies and Evolution”, The Institution of Engineering and Technology, 2017
2. James Momoh, “Smart Grid - Fundamentals of Design and Analysis”, IEEE Press, John Wiley and Sons, 2012

REFERENCES:

1. Takuro Sato, Daniel M. Kammen, Bin Duan, Muhammad Tariq, Zhenyu Zhou, Jun Wu and Solomon Abebe Asfaw, “Smart Grid Standards - Specifications, Requirements, and Technologies”, John Willey and Sons, 2015
2. Stuart Borlase, “Smart Grids Advanced Technologies and Solutions”, CRC Press, 2nd Edition, 2018
3. Ali Keyhani, “Design of Smart Power Grid Renewable Energy Systems”, John Willey and Sons, 3rd Edition, 2019

EVALUATION PATTERN:*

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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

U21EEP12	HVDC TRANSMISSION	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To develop the ability to identify the principles, configurations, and applications of HVDC transmission systems.
- To build analytical competence in examining the operation, control strategies, and converter technologies used in HVDC systems.
- To foster understanding of reactive power management, harmonic mitigation techniques, and power flow in HVDC networks.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify the principles, configurations, and applications of DC and HVDC transmission systems including MTDC networks. (Apply)
CO2: Examine the operation and performance of line-commutated and voltage source converter (VSC) based HVDC converters. (Analyze)
CO3: Distinguish control strategies of HVDC systems including firing angle control, current control, extinction angle control, and VSC control schemes. (Analyze)
CO4: Analyze the design considerations for reactive power compensation and harmonic filtering in HVDC systems. (Analyze)
CO5: Utilize power flow analysis techniques to HVDC systems under steady-state operating conditions. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	-
CO2	3	3	2	2	1	-	-	-	-	-	-	1	2	-
CO3	3	3	2	2	1	-	-	-	-	-	-	1	2	-
CO4	3	3	2	2	1	-	1	-	-	-	-	1	2	-
CO5	3	2	1	1	-	-	1	-	-	-	-	1	2	-
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I **DC POWER TRANSMISSION TECHNOLOGY** **9**

Comparison of AC and DC transmission – DC transmission – Applications and Description – Planning for HVDC transmission – Modern trends in HVDC technology – Types and applications of Multi Terminal DC (MTDC) systems – HVDC transmission in India.

UNIT II HVDC CONVERTERS **9**

Line commutated converter – Analysis of Graetz circuit with and without overlap – Pulse number – Choice of converter configuration – Converter bridge characteristics – Analysis of 12 pulse converters – Analysis of IGBT based VSC topologies and firing schemes.

UNIT III CONTROL OF HVDC SYSTEMS **9**

Principles of DC link control – Converter control characteristics – System control hierarchy – Firing angle control – Current and extinction angle control – Starting and stopping of DC link – Power control – Higher level controllers – Control of VSC based HVDC link.

UNIT IV REACTIVE POWER AND HARMONIC CONTROL **9**

Reactive power requirements in steady state – Sources of reactive power – SVC and STATCOM – Generation of harmonics – Design of AC and DC filters – Active filters.

UNIT V POWER FLOW ANALYSIS **9**

Per unit system for DC quantities – DC system model – Inclusion of constraints – Power flow analysis – Case study.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. K. R. Padiyar, “HVDC Power Transmission System”, New Academic Science Limited, New Delhi, 2nd edition, 2017
2. S. Kamakshaiah and V. Kamaraju, “HVDC Transmission”, McGraw-Hill Education Private Limited, 2nd edition, 2020

REFERENCES:

1. Dragan Jovcic, “High Voltage Direct Current Transmission: Converters, Systems and DC Grids”, John Wiley and Sons, 2nd edition, 2019
2. Chan-Ki Kim, Vijay K. Sood, “HVDC Transmission: Power Conversion Application in Power Systems”, John Wiley and Sons, 2009

EVALUATION PATTERN:

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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

U21EEP13	ADVANCED ELECTRIC MOTORS AND CONTROL	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- NIL

COURSE OBJECTIVES:

- To provide knowledge of special electrical machines and their operating principles
- To present control methods used in special machine drives
- To introduce application and selection aspects of special motor drives

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Examine the operation and performance of synchronous reluctance motors (Analyze)

CO2: Analyze the characteristics and control of permanent magnet synchronous motors (Analyze)

CO3: Design the control circuits for switched reluctance motors (Apply)

CO4: Investigate the performance of BLDC motors with reference to efficiency standards (Analyze)

CO5: Analyze the topology and control methods of axial flux machines (Analyze)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	1	-	-	-	-	-	-	1	3	-
CO2	3	3	2	-	2	-	-	-	-	-	-	1	3	-
CO3	3	2	2	-	2	-	-	-	-	-	-	1	3	-
CO4	3	3	2	-	2	-	-	-	-	-	-	1	3	-
CO5	3	3	2	-	2	-	-	-	-	-	-	1	3	-
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I SYNCHRONOUS RELUCTANCE MOTOR 9

Constructional features – Principle of operation – Characteristics – Open loop and closed loop control – Microprocessor based control – Sensor less control – Applications

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTOR 9

Construction – Principle of operation – EMF, power input and torque expressions – Power controllers – Torque speed characteristics – Self-control – Vector control – Current control schemes – Sensor less control

UNIT III SWITCHED RELUCTANCE MOTOR **9**

Constructional features – Modes of excitation – Torque prediction – Characteristics – Steady state performance prediction – Power controllers – Control of SRM drive – Sensor less operation of SRM

UNIT IV BLDC MOTOR **9**

PMBLDC: Constructional features – Types – Principle of operation – Drive schemes – Converter topologies – Characteristics – Intelligent control.

UNIT V AXIAL FLUX MOTOR AND ENERGY EFFICIENCY STANDARD **9**

Axial Flux motor – types of axial flux motor – Principle of operation – AFPM control method – Characteristics of PM materials – Control of trapezoidal AFPM – Solid state converter – Standard motor efficiency – Efficiency evaluation technique – Motor efficiency labelling

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Vedam Subramanyam, “Electric Drives - Concepts and Applications”, 2nd edition, McGraw Hill, 2010
2. Jacek F. Gieras Rong-Jie Wang Maarten J. Kamper., “Axial Flux Permanent Magnet Brushless Machines”,2nd edition, Springer, 2008

REFERENCES:

1. Diane Lobsiger ., “Electrical Control for Machines” 7th edition Cengage Learning, 2015
2. Ned Mohan, “Advanced Electric Drives: Analysis, Control and Modeling using MATLAB / Simulink”, Wiley, 2014
3. https://en.nanotec.com/knowledge-base/stepper-motor-animation

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

U21EEP17	BATTERY MANAGEMENT SYSTEMS		Category: PEC			
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To establish a strong foundation in battery technologies and energy storage principles.
- To develop comprehensive understanding of battery management system architecture, sensing, and protection techniques.
- To enable the application of modeling, estimation, and design concepts in battery management systems for electric vehicle applications.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Calculate battery voltage, capacity, energy and power for given configurations accurately. (Apply)

CO2: Determine BMS functional requirements including sensing, protection and thermal management for applications. (Apply)

CO3: Implement SOC and SOH estimation techniques using voltage-based and model-based methods effectively. (Apply)

CO4: Simulate equivalent-circuit battery models and vehicle range under defined operating parameters. (Apply)

CO5: Design battery management systems considering balancing strategies, load variations and life constraints. (Apply)

CO-PO MAPPING:

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

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I BASIC CONCEPTS OF BMS **9**

Introduction to Battery Management System – Cells & amp – Batteries – Nominal voltage and capacity – C rate – Energy and power – Cells in series – Cells in parallel – Electrochemical and lithium-ion cells – Flow Battery – Rechargeable cell

UNIT II BATTERY MANAGEMENT SYSTEM **9**

BMS functionality – Sensing unit – High-voltage contactor control – Isolation sensing and thermal control – Protection and interface – Energy and power estimation

UNIT III SENSING AND CONTROL OF BATTERY MANAGEMENT SYSTEM **9**

Battery state of charge estimation (SOC) – Voltage-based method – Model-based state estimation – Battery Health Estimation – Lithium-ion aging: Negative electrode – Positive electrode – Cell balancing – Causes of imbalance – Circuits for balancing

U21EEP21	ELECTRIC VEHICLES IN SMART GRID	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To establish a strong knowledge base in vehicle electrification and the impact of charging strategies on power systems.
- To develop understanding of the influence of electric vehicles on power system operation and stability.
- To enable the application of frequency control and voltage support services using electric vehicles.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Determine EV charging load impacts on power systems under specified conditions. (Apply)
CO2: Calculate EV penetration effects on grid performance for defined demand scenarios. (Apply)
CO3: Implement vehicle-to-grid control strategies using given system parameters. (Apply)
CO4: Apply communication protocols for EV integration in smart grid environments. (Apply)
CO5: Design EV charging infrastructure for specified microgrid conditions. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO3	3	2	2	1	-	-	-	-	-	-	-	-	-	2
CO4	3	2	1	1	-	-	-	-	-	-	-	-	-	2
CO5	3	2	1	1	-	-	-	-	-	-	-	-	-	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I IMPACT OF CHARGING SYSTEM **9**

EV charging options and infrastructure – Impact of charging strategies – Energy, economic and environmental considerations – Effect of EV charging on generation and load profile – Smart charging technologies – Impact on investment

UNIT II INFLUENCE OF EVS ON POWER SYSTEM **9**

Identification of EV demand – EV penetration level for different scenarios – Classification based on

penetration level – EV impacts on system demand: dumb charging, multiple tariff charging, smart charging

UNIT III FREQUENCY CONTROL RESERVES & VOLTAGE SUPPORT FROM EVS 9

Power system ancillary services – Electric vehicles to support wind power integration – Electric vehicle as frequency control reserves and tertiary reserves – Voltage support and electric vehicle integration – Properties of frequency regulation reserves – Control strategies for EVs to support frequency regulation

UNIT IV ICT SOLUTIONS TO SUPPORT EV DEPLOYMENT 9

Architecture and model of smart grid – ICT role in smart grid – Smart metering, information and communication models – Functional and logical models – Technology and solution for smart grid: interoperability – Communication technologies

UNIT V EV CHARGING FACILITY PLANNING 9

Energy generation scheduling – Different power sources – Fluctuant electricity – Centralized charging schemes – Decentralized charging schemes – Energy storage integration into Microgrid – Design of V2G Aggregator

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Sumedha Rajakaruna, Farhad Shahnia, Arindam Ghosh, “Plug In Electric Vehicles in Smart Grids”, 2nd edition Springer Nature, 2015.
2. Junwei Lu, Jahangir Hossain, “Vehicle-to-Grid: Linking electric vehicles to the smart grid”, Institution of Engineering and Technology, 2015.

REFERENCES:

1. Wanrong Tang , Ying Jun (Angela) Zhang, " Optimal Charging Control of Electric Vehicles in Smart Grids ", Springer Nature, 2017.
2. Crouse W.H, Anglin D.L, "Automotive Transmission and Power Train construction", McGraw Hill, 2000.
3. Harald Naunheimer , Bernd Bertsche , Joachim Ryborz , Wolfgang Novak "Automotive Transmission: Fundamentals, Selection, Design and Application", 2nd Edition, Springer, 2011

EVALUATION PATTERN:

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U21EEP23	ENERGY STORAGE SYSTEMS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To establish foundational concepts of electric vehicle architecture and powertrain components.
- To provide in-depth understanding of energy storage system principles in electric vehicles.
- To foster the ability to implement IoT paradigms in electric vehicle applications.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Utilize energy market concepts to study structural issues in the Indian energy sector. (Apply)

CO2: Implement performance assessment methods to study different battery storage systems for suitable applications. (Apply)

CO3: Execute thermoelectric measurements using appropriate techniques. (Apply)

CO4: Employ selection criteria to choose suitable supercapacitors for specific energy storage applications. (Apply)

CO5: Demonstrate appropriate methods to compare and choose fuel cells for practical energy applications. (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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CO4	3	3	2	1	-	-	-	-	-	-	-	1	3	-
CO5	3	3	2	1	-	-	-	-	-	-	-	1	3	-
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)				3: Substantial (High)							

SYLLABUS:

UNIT I INTRODUCTION TO ENERGY STORAGE **9**

Prospect for both traditional and renewable energy sources – Detailed analysis of Indian energy market and future need – Energy, economic growth and the environment – Implications of Kyoto Protocol – Structural change in electricity supply industry

UNIT II STORAGE SYSTEMS **9**

Batteries – Performance – charging and discharging – storage density – energy density and safety issues – classical batteries: Lead Acid – Nickel-Cadmium – Zinc Manganese dioxide and modern batteries – Zinc – Air – Nickel Hydride – Lithium Battery – Fuel cell – Fly wheel

UNIT III THERMOELECTRIC BATTERY **9**

Thermoelectric – Electron conductor and phonon glass – Classical thermoelectric materials – Probe resistivity measurement – Seebeck coefficient measurement, and thermal conductivity measurement

UNIT IV SUPER CAPACITORS **9**

Super capacitors – Types of electrodes and electrolytes – Electrode materials – High surface area activated carbons – Metal oxide – Conductive polymers – Electrolyte – Aqueous – Applications transport vehicles – private vehicles and consumer electronics – energy density – power density and market

UNIT V FUEL CELLS **9**

Fuel cells – Direct energy conversion – Maximum intrinsic efficiency of an electrochemical converter, Physical interpretation – Carnot efficiency factor in electrochemical energy convertors – Types of fuel cells – Hydrogen oxygen cells – Hydrogen air cell – Aalkaline fuel cell – Phosphoric fuel cell

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Tetsuya Osaka, Madhav Datta, 'Energy Storage Systems in Electronics', Gordon and Breach, 2000
2. A.G.Ter-Gazarian, "Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology (IET) Publication, UK, 2011.

REFERENCES:

1. D.M. Rowe, 'Thermoelectrics Handbook: Macro to Nano', CRC Press, 2006
2. James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.
3. Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.

EVALUATION PATTERN:

Continuous Internal Assessments					**End Semester Examinations**
Assessment I (100		**Assessment II (100**		**Total Internal Assessments**	
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				10	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical

U21EEP24	IoT IN EV APPLICATIONS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To establish foundational concepts of electric vehicle architecture.
- To develop understanding of the impact of IoT technologies in electric vehicles.
- To foster the ability to implement IoT paradigms in electric vehicle applications.

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Implement IoT concepts in basic engineering applications. *(Apply)*

CO2: Utilize drive-train topologies and propulsion techniques in electric vehicle systems. *(Apply)*

CO3: Solve problems related to vehicle mechanics using fundamental principles. *(Apply)*

CO4: Design hybrid energy storage configurations for electric vehicle applications. *(Apply)*

CO5: Develop IoT-based solutions for electric vehicle applications. *(Apply)*

CO-PO MAPPING:

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

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I PHYSICAL DESIGN OF IoT **9**

IoT System – Characteristics – Logical design – IoT protocols – IoT levels and deployment templates – Need for IoT system management – Network operator requirements – Differences and similarities between M2M and IoT

UNIT II ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS **9**

Evolution of Electric Vehicles – Impact of modern drive trains on energy supplies – Architecture of Electric vehicles and hybrid electric vehicles – Plug-in hybrid electric vehicles – Power train components and sizing, gears, clutches, transmission and brakes

UNIT III MECHANICS OF ELECTRIC VEHICLES 9

Fundamentals of vehicle mechanics – Tractive force, power and energy requirements for standard drive cycles of HEVs – Motor torque, Power rating and battery capacity – Range-extended electric vehicles: classification and configurations, fuel cell electric vehicles, solar electric vehicles, electric bi-cycles and their propulsion systems, vehicle-to-grid, vehicle-to-home concepts

UNIT IV ENERGY STORAGE SYSTEMS 9

Storage requirements – Battery – Fuel cell – Super Capacitor – Power pack management systems – Cell balancing techniques – Flywheel based energy storage and its analysis – Hybridization of different energy storage devices – Compressed air storage systems – Super conducting magnetic storage systems

UNIT V IoT APPLICATIONS 9

Case Study – Autonomous electric vehicles – Connected vehicles – Electric vehicle charging

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Ali Emadi, “Advanced Electric Drive Vehicles”, CRC Press, Taylor & Francis Group, 2015
2. Husain I., “Electric and Hybrid Vehicles”, Boca Raton, CRC Press, 2010

REFERENCES:

1. Sheldon S. Williamson, “Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles”, Springer, 2013
2. Arshdeep Bahga and Vijay Madisetti, “Internet of Things - A Hands on Approach”, Universities Press, 2015
3. Jack Erjave C. and Jeff Arias, “Alternate Fuel Technology - Electric, Hybrid and Fuel Cell Vehicles”, Cengage, 2012

EVALUATION PATTERN:

Continuous Internal Assessments					**End Semester Examinations**
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	
*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Mini Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

VERTICAL II – MEDICAL DEVICE DEVELOPMENT AND MANAGEMENT

U21BMP13	MEDICAL DEVICE REGULATIONS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE-REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the regulations for medical devices
- To explore the assessment methods adopted for the quality sustenance in hospitals
- To identify the various regulatory standards and certifications

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Explain the international regulatory framework of medical device (Understand)

CO2: Describe the quality management system and risk management (Understand)

CO3: Discuss the technical documentations involved in regulatory process (Understand)

CO4: Explore premarket phase of medical device regulatory process (Understand)

CO5: Outline the post market phase and various regulatory standards and certifications (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	1	1	-	-	-	-	-	1	-
CO2	2	1	-	-	-	1	1	-	-	-	-	-	1	-
CO3	2	1	-	-	-	1	1	-	-	-	-	-	1	-
CO4	2	1	-	-	-	1	1	-	-	-	-	-	1	-
CO5	2	1	-	-	-	1	1	-	-	-	-	-	1	-
Correlation levels:	1: Slight (Low)		2: Moderate (Medium)			3: Substantial (High)								

SYLLABUS:

UNIT I OVERVIEW OF THE INTERNATIONAL REGULATORY FRAMEWORK FOR MEDICAL DEVICES **9**

Established and emerging markets – Credibility and authority of approvals – Medical device life cycle – Definitions of medical devices – Active implantables and in vitro diagnostics – Borderline products – Combination products – EU – US – Australian – Canadian – Japanese regulations for combination products – Risk-based Classification – Classification philosophies

UNIT II QUALITY MANAGEMENT SYSTEM AND RISK MANAGEMENT **9**

General principles and the use of standards – Standards organizations – Standards applicable to medical devices – Software and firmware – Software regulations – RF wireless devices –

Cybersecurity – Hazardous substances contained in electronic devices – Medicines and biologics – Tissues of animal origin susceptible to TSE – Phthalates – Allergens

UNIT III TECHNICAL DOCUMENTATION 9

Documentation mandated by EU – US – Australian – Canadian – Japanese – GHTF summary technical documentation – Example of STED-Aligned DHF – Manufacturing information – Verification and validation – Clinical evaluation – Regulated product submission – Regulatory submissions repository – Case study: The Scattered DHF

UNIT IV PRE-MARKET PHASE 9

Design controls – Information management during the Pre-Market phase – D and D planning stage – D and D process stage – Product identification and traceability – Case study – Regulatory submissions – Approvals and registrations

UNIT V POST-MARKET PHASE 9

Product launch – Continued regulatory compliance – Change management – Post-Market surveillance – Regulatory systems and processes – Case study: Square peg in a round hole note on ISO 13485 – ISO 15378 - ISO 14971 – ISO 10993 – IEC 60601

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Almir Badnjević, “Inspection of Medical Devices: For Regulatory Purposes”, Springer, 1st edition, 2018
2. Val Theiz, "Medical Device regulatory practices: An international Perspective", Pan Stanford, 1st edition, 2015

REFERENCES:

1. Jack Wong, “Medical Regulatory Affairs: An International Handbook for Medical Devices and Healthcare Products” Jenny Stanford Publishing; 3rd edition, 2022
2. Jack Wong, Handbook of Medical Device Regulatory Affairs in Asia: Second edition, Jenny Stanford Publishing; 2nd edition, 2018

EVALUATION PATTERN:

<table>
<tr><th colspan="5">Continuous Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
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(100 Marks)</th><th rowspan="2">Total Internal Assessments</th></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td></tr>
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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

VERTICAL II – MEDICAL DEVICE DEVELOPMENT AND MANAGEMENT

U21BMP15	MEDICAL WASTE MANAGEMENT	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE-REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the hazardous materials used in hospital and its impact on health
- To familiarize with various waste disposal procedures and management
- To interpret the regulations and safety norms to be followed in medical waste management

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Identify different types of wastes generated from hospitals (Understand)

CO2: Understand the basic steps to be followed while segregating wastes (Understand)

CO3: Summarize various treatment techniques for medical wastes (Understand)

CO4: Illustrate and manage different types of hazardous medical wastes methods (Understand)

CO5: Outline various regulations and safety norms (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	1	1	1	-	-	-	1	1	-
CO2	2	-	-	-	-	1	1	1	-	-	-	1	1	-
CO3	2	-	-	-	-	1	1	1	-	-	-	1	1	-
CO4	2	-	-	-	-	1	1	1	-	-	-	1	1	-
CO5	1	-	-	-	-	1	1	1	-	-	-	1	1	-
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)				3: Substantial (High)						

SYLLABUS:

UNIT I INTRODUCTION TO MEDICAL WASTE **9**

General and Hazardous health care waste, Infectious waste, Genotoxic waste, Waste sharps – Colour coding – Sources of health care wastes – bio hazard symbols

UNIT II HANDLING MEDICAL WASTE MANAGEMENT **9**

Basic steps in segregation – Sharp decontaminating – Disinfections container for autoclaving – Sharp waste containers for storage and transportation – Shredding – Incrimination – Hydropulbing – Plasma tonch

UNIT III CONVENTIONAL TREATMENT TECHNOLOGIES **9**

Wet thermal technology – Incineration – Microwave technology – Rotaclave system – Hydro clave system – Electro Thermal Reactivation (ETP) Treatment Process – Electron beam technology – Plasma pyrolysis

UNIT IV HAZARDOUS WASTES TREATMENT **9**

Hazardous substance safety – OSHA hazard communication standard – DOT hazardous material regulations – Medical gas systems – Respiratory protection

UNIT V LEGISLATION AND POLICIES ON MEDICAL WASTE MANAGEMENT **9**

Biomedical waste management and handling rules, 1998 and its amendment – Safe disposal of radioactive waste rules, 1995 guideline of BARC – CPCB guidelines

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Tweedy, James T., "Healthcare hazard control and safety management", CRC Press Taylor and Francis, 1st edition, 2014
2. Anantpreet Singh, Sukhjit Kaur, Biomedical Waste Disposal, Jaypee Brothers Medical Publishers (P) Ltd, 1st edition, 2012

REFERENCES:

1. Safe disposal of Radioactive waste Rules, 1995 guideline of BARC
2. R.C.Goyal, "Hospital Administration and Human Resource Management Ⅱ", PHI publications, 4th edition, 2006

EVALUATION PATTERN:

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<tr><td colspan="4">Continuous Internal Assessments</td><td rowspan="2">Total Internal Assessments</td><td rowspan="2">End Semester Examinations</td></tr>
<tr><td colspan="2">Assessment I
(100 Marks)</td><td colspan="2">Assessment II
(100 Marks)</td></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td><td>*Individual Assignment / Case Study / Seminar / Project / MCQ</td><td>Written Test</td><td></td><td></td></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

VERTICAL III - MECHANICS

U21BMP20	ASSISTIVE TECHNOLOGY	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE-REQUISITES:

- U21BM306 - Biomedical Sensors and Instrumentation

COURSE OBJECTIVES:

- To make the students aware of the available assistive technology to improve the quality of life of disabled persons
- To know the challenges in design and implementation of these assistive products
- To engage the students in creating simple applications using the available technology

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Analyze the use of CAT models in different applications and comprehend the need of the model in design of assist devices (Understand)

CO2: Depict the design of available speech, text and Braille conversion applications (Apply)

CO3: Examine various cases and understand the pros and cons of implementing OCR and DAISY technology **(**Apply)

CO4: Develop a simple module for implementing assist technology for daily living with their expertise **(**Apply)

CO5: Identify the role of assistive technologies in education, employment and recreation (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-	2	-
CO4	3	3	2	-	-	-	-	-	-	-	-	-	2	-
CO5	2	-	-	-	-	-	-	-	-	-	-	-	2	-
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

SYLLABUS:

UNIT I INTRODUCTION TO ASSISTIVE TECHNOLOGY SYSTEMS **9**

Social context of disability – Quality of life on using assistive technology – Modeling assistive technology systems – Comprehensive Assistive Technology (CAT) models – Usage of CAT models in real time

UNIT II SPEECH, TEXT AND BRAILLE CONVERSION TECHNOLOGY **9**

Prerequisite for speech, text and conversion technology – Pattern and speech recognition systems – Principles of speech synthesis – Text to Braille and Braille to Text conversion systems –Commercial equipment and its application – Haptic Technology

UNIT III ASSISTIVE TECHNOLOGY FOR ACCESSING BOOKS AND DOCUMENTS 9

Challenges in accessing printed pages – Optical Character Recognition (OCR) technology – Reading systems – DAISY technology – Accessing textbooks and newspapers – Accessible music software for print impaired people

UNIT IV ASSISTIVE TECHNOLOGY FOR DAILY LIVING 9

Personal Care – Timekeeping, Alarms and Alerting – Assistive Technology for food preparation and consumption – Environmental control – Mobility Aids – Money, Finance and shopping – Communication and access to public information

UNIT V ASSISTIVE TECHNOLOGY FOR EDUCATION, EMPLOYMENT AND RECREATION 9

Accessing Educational processes and approaches – Educational Technologies, devices and tools technologies for professional, person-centered employment – Games, Puzzles, Toys – Access to sports and outdoor games – Assistive technology in tourists places – Wayfinding systems

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Bryant, Diane P., and Brian R. Bryant "Assistive technology for people with disabilities", Pearson Higher Ed, 2011
2. Hersh, Marion A Ed., and Michael A. Johnson, "Assistive technology for visually impaired and blind people", Springer, 2008

REFERENCES:

1. Suraj Singh Senjam, "Introduction to Assistive Technology", Nova Science Publishers, 2021
2. Emily C. Bouck, "Assistive Technology", SAGE Publications, Inc, 2016

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th rowspan="3">Total Internal Assessments</th><th rowspan="3">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I (100 Marks)</th><th colspan="2">Assessment II (100 Marks)</th></tr>
<tr><th>*Individual Assignment / Case Study / Seminar / Project / MCQ</th><th>Written Test</th><th>*Individual Assignment / Case Study / Seminar / Project / MCQ</th><th>Written Test</th></tr>
<tr><td>40</td><td>60</td><td>40</td><td>60</td><td>200</td><td>100</td></tr>
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*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Coordinator can choose any one / two components based on the nature of the course.

SEMESTER VII

U21BMX02	Biometric Systems	Category: PCC				
		L	T	P	J	C
		3	0	2	0	4

PRE–REQUISITES:

- U21BM301 – Human Anatomy and Physiology
- U21BM603 – Biomechanics

COURSE OBJECTIVES:

- To identify the engineering concepts that can be applied in rehabilitation medicine and the role of engineers in various rehabilitation disciplines
- To illustrate the different types of therapeutic exercise technique
- To interpret the various orthotic devices and prosthetic devices to overcome orthopedic problems

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Summarize the principles of rehabilitation system (Understand)

CO2: Identify various exercises involved in rehabilitation process (Apply)

CO3: Analyze rehabilitation management in communication (Analyze)

CO4: Apply restoration techniques in rehabilitation (Apply)

CO5: Contrast the effectiveness of rehabilitation (Analyze)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	1	-	-	-	-	-	1	1	-
CO2	3	2	1	-	-	1	-	-	-	-	-	1	1	1
CO3	3	2	1	-	1	1	-	-	-	-	-	1	1	-
CO4	3	2	2	-	1	-	-	-	-	-	-	1	1	1
CO5	3	2	3	-	1	1	-	-	-	-	-	1	1	1
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I PRINCIPLE OF REHABILITATION ENGINEERING 6

Introduction to rehabilitation – Epidemiology of rehabilitation – Health – Levels of prevention – Preventive rehabilitation – Diagnosis of disability – Functional diagnosis – Importance of psychiatry in functional diagnosis – Impairment – disability – handicap – Primary and secondary disabilities – Clinical practice of rehabilitation engineering – Design based on human ability

UNIT II THERAPEUTIC EXERCISE TECHNIQUE 6

Co-ordination exercises – Frenkels exercises – Relaxation exercises – Strengthening exercises – Types of contraction – Mobilization exercises – Endurance exercises

UNIT III MANAGEMENT OF COMMUNICATION **6**

Impairment – Aphasia – Types of aphasia – Treatment of aphasic patient – Augmentative communication – General form of communication – Types of visual aids – Hearing aids

UNIT IV ORTHOTIC, PROSTHETIC DEVICES AND RESTORATIONTECHNIQUES **6**

General orthotics – Classification of orthotics – Functional and regional General principles of orthosis – Calipers – FO – AFO – KAFO – HAFO – Body powered prosthetics – Myoelectric controlled prosthetics – Functional electrical stimulation systems – Restoration of hand function – Restoration of standing and walking

UNIT V CASE STUDY **6**

Geriatric Rehabilitation – Visual and auditory challenges faced by geriatrics and methods to overcome those challenges– Pediatric rehabilitation – Visual and auditory challenges faced by cerebral palsy – Muscular dystrophy and autism children – Methods to overcome those challenges

LIST OF EXPERIMENTS (INDICATIVE)

1. Analyze lateral trunk control using rehametrics.
2. Observe the cognitive analysis on dynamic and static balance.
3. Real time monitoring of shoulder range of motion.
4. Record the anteroposterior centre of mass displacement.
5. Design, development and interfacing of EMG controlled prosthetics / bionic arm.
6. Study of hip flexion and adduction.

Contact Periods:

Lecture: 30 Periods Tutorial: – Periods Practical: 30 Periods Project: – Periods

Total: 60 Periods

TEXT BOOKS:

1. S Sunder, “Textbook of Rehabilitation”, 4th Edition, Jaypee Brothers Medical Publishers private limited, NewDelhi, 2019
2. Joseph D. Bronzino, “The Biomedical Engineering Handbook”, 3rd Edition, Taylor and Francis, 3 volume set, 2006

REFERENCES:

1. Rory A. Cooper, Hisaichi Ohnabe and Douglas A.Hodson, “An Introduction to Rehabilitation Engineering” , 1st Edition, CRC Press, 2014
2. Marion A. Hersh and Michael A. Johnson, “Assistive Technology for Visually impaired and blind people”, 1st E dition, Springer Verlag, 2014

EVALUATION PATTERN:

<table>
<tr><th colspan="4">Continuous Internal Assessments</th><th colspan="2" rowspan="2">End Semester Examinations</th></tr>
<tr><th colspan="2">Assessment I
(Theory)
(100 Marks)</th><th colspan="2">Assessment II
(Practical)
(100 Marks)</th></tr>
<tr><td>*Individual Assignment / Case Study / Seminar / Mini Project / MCQ</td><td>Written Test</td><td>Evaluation of Laboratory Observation, Record
(Rubrics Based Assessments)</td><td>Test</td><td rowspan="2">Theory Examinations (Examinations will be conducted for 100 Marks)</td><td rowspan="2">Practical Examinations (Examinations will be conducted for 100 Marks)</td></tr>
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PROFESSIONAL ELECTIVE

U21CEP08	Urban Waste Water Engineering	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES

- Nil

COURSE OBJECTIVES

- To discuss the source and characteristics of Industrial wastewater
- To deliberate the Preliminary treatment of industrial wastewater from different industries
- To provide knowledge on disposal options for specific pollutants arising out of industrial processes

COURSE OUTCOMES

Upon completion of the course, the student will be able to

CO1: identify the properties of industrial wastewater **(**Understand)

CO2: interpret the industrial process, water utilization and waste reduction **(**Understand)

CO3: examine the characteristics and composition of industrial wastewater **(**Understand)

CO4: choose appropriate treatment method for industrial wastewater **(**Understand)

CO5: design the effluent treatment plant for any industry (Apply)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	-	1	1	-	-	-	-	-	-	-
CO2	1	1	-	-	-	1	1	-	-	-	-	-	-	-
CO3	1	1	-	-	-	1	1	-	-	1	-	-	-	2
CO4	1	1	-	-	-	1	1	-	-	1	-	-	-	2
CO5	1	1	2	-	-	1	1	1	-	1	-	-	-	2
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I INTRODUCTION **9**

Basic theories of industrial wastewater management – Sources of pollution – Physical, Chemical, Organic & Biological properties of industrial Wastes – Difference between industrial & municipal wastewater – Effects of industrial effluents on sewers and Natural water Bodies

UNIT II VOLUME AND STRENGTH REDUCTION **9**

Pre & Primary Treatment – Equalization, Proportioning, Neutralization, recovery and recycling of waste products and by products, Oil separation by Floating – Waste reduction – Volume reduction– Strength reduction – Joint treatment of industrial wastes and domestic sewage

UNIT III CHARACTERISTICS AND COMPOSITION 9

Characteristics and Composition of wastewater -- Manufacturing Processes of Industries like Sugar, Distilleries, Dairy, Textiles, Tanneries, fertilizer, Food processing Industries, Steel, and Petroleum refineries – Case studies

UNIT IV TREATMENT OF INDUSTRIAL WASTE 9

Waste Treatment Methods – Nitrification and De-nitrification – Phosphorous removal – Heavy metal removal – Membrane Separation Process – Special Treatment Methods – Disposal of treated wastewater

UNIT V COMBINED TREATMENT 9

Common Effluent Treatment Plants (CETP) – Site selection, Design, Operation and Maintenance Problems – Economical aspects – **Sustainable approaches in waste water and sludge disposal**

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Project 0 Periods

Total 45 Periods

TEXTBOOKS:

1. Metcalf & Eddy, “Wastewater engineering Treatment disposal reuse”, Tata McGraw Hill.2009.
2. Eckenfelder, W.W., “Industrial Water Pollution Control”, McGraw-Hill.2001

REFERENCE BOOKS:

1. M.N. Rao and Dutta “Industrial Waste”. Oxford & IBH Publishing Co Pvt.Ltd.2005.
2. Mark J. Hammer, Mark J. Hammer, Jr., “Water & Wastewater Technology”, Prentice Hall of India.2009
3. N.L.Nemerrow “Theories and practices of Industrial Waste Engineering”. Addison-Wesley.2009.
4. C.G.Gurnham “Principles of Industrial Waste Engineering” Wiley.2005

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided.

PROFESSIONAL ELECTIVE

U21CEP09	MUNICIPAL SOLID WASTE MANAGEMENT	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To acquire knowledge on the reduction, segregation, and storage of wastes at sources
- To study the importance of transfer stations and processing technologies for resource recovery
- To enumerate and describe different disposal and treatment methods for municipal solid waste

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: classify the sources, types and effects of municipal solid wastes (Understand)

CO2: identify the methods of on-site storage and its process in solid waste management (Understand)

CO3: select the methods of collection involved in solid waste management (Apply)

CO4: demonstrate the off-site processing techniques in solid waste management (Understand)

CO5: summarize the various disposal methods of solid wastes (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	2	2	1	-	-	-	-	-	-
CO2	1	-	-	-	-	2	2	-	-	-	-	1	2	-
CO3	1	-	-	-	1	2	2	-	-	-	-	1	2	-
CO4	1	-	-	-	1	2	2	1	-	-	-	-	-	-
CO5	1	-	-	-	-	2	2	1	-	-	1	1	2	1
Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)														

SYLLABUS:

UNIT I SOURCES AND EFFECTS OF SOLID WASTE **9**

Sources and types of municipal solid waste – Waste generation rates – Factors affecting waste generation, composition, characteristics – Methods of sampling – Effects of improper disposal of solid wastes – Public health and environmental effects – Elements of solid waste management – Municipal solid waste rules – Role of NGO's, EPA.

UNIT II SOURCE REDUCTION, WASTE STORAGE AND RECYCLING **9**

Source reduction of waste – Reduction, Reuse, Recycling and Recover – Segregation of wastes at source – Onsite storage methods – Materials used for containers – Public health & economic aspects of storage – Case studies under Indian conditions; Recent advances – Smart bins

UNIT III COLLECTION AND TRANSFER 9

Methods of Collection – Types of vehicles – Vehicle time management – Manpower requirement – Collection routes; transfer stations – Selection of location, operation & maintenance; options under Indian conditions; Recent advances – **Smart waste bin collection**, Fleet collection system

UNIT IV PROCESSING AND DISPOSAL OF WASTES 9

Objectives of waste processing – Physical Processing techniques and Equipment – Composting – Bio methanation – Incineration, Disposal of solid wastes: Sanitary landfills – Design and operation of sanitary landfills – Leachate collection and treatment; Recent advances –**Automation in waste segregation**, Biomining

UNIT V INTEGRATED SOLID WASTE MANAGEMENT 9

ISWM: Definition – Challenges and opportunities – Life cycle, Generation source and Stakeholders perspective – Benefits, Plan, Activities and Strategy of ISWM – **Case studies on ISWM** – **Circular Economy Principles in waste management**

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. William, A. Worrell., P. Aarne Vesilind., "Solid Waste Engineering", Cengage Learning, 2012.
2. John Pitchel., "Waste Management Practices-Municipal, Hazardous and industrial", CRC Press, Taylor and Francis, New York, 2014.
3. Ramachandra, T. V., "Management of Municipal Solid Waste", TERI Press, New Delhi, 2009.

REFERENCES:

1. CPHEEO, "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation," Government of India, New Delhi, 2014.
2. George Tchobanoglous and Frank Kreith., "Handbook of Solid waste management," McGraw Hill, New York, 2002.
3. Marc J. Rogoff and Francois Screve., "Waste to Energy Technologies and Project Implementation," Second Edition, Noyes Publication, USA, 2011.
4. Mushtaq Ahemd MEMON, "Integrated solid waste management," International environmental technology centre (IETC), OSAKA - Japan.

EVALUATION PATTERN:

Continuous Internal Assessments					**End Semester Examinations**
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided.

PROFESSIONAL ELECTIVE

U21CEP10	ENVIRONMENTAL IMPACT ANALYSIS	Category: PEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES

- Nil

COURSE OBJECTIVES

- To highlight the evolution of Environmental impact assessment methods
- To introduce the Impact assessment methods for various projects
- To explain the various components for preparing the EIA document

COURSE OUTCOME

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

CO1: understand the background of Environmental impact assessment (Understand)

CO2: perform impact assessment methods for various projects (Understand)

CO3: formulate the EIA report (Understand)

CO4: prepare an environmental management plan (Understand)

CO5: summarize the various EIA studies (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	1	1	1	-	-	-	-	1	-
CO2	1	-	-	-	-	1	1	1	-	-	-	-	1	-
CO3	1	3	1	-	-	1	1	1	-	2	-	-	1	-
CO4	1	3	1	-	-	1	1	1	-	2	-	-	1	-
CO5	1	3	1	-	-	1	1	1	-	2	-	-	1	-
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION **9**

Concept of environment – Environmental impact, Environmental impact assessment (EIA) – Definitions, terminology and overview – Evolution of EIA in the USA, Key features of the National Environmental Policy Act and its implementation and the Council on Environmental Quality (CEQ) guidelines.

UNIT II METHODOLOGIES **9**

Methods of EIA – Check lists – Matrices – Networks – Cost-benefit analysis – Analysis of alternatives

UNIT III PREDICTION AND ASSESSMENT **9**

Assessment of Impact on land, surface water, groundwater, air, social & cultural activities – Flora &

fauna-Mathematical models – Evaluation of alternatives, Preparing the EIA document – Environmental impact statement (EIS), Environmental monitoring, Environmental audit (EA)

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 9

EMP preparation – Monitoring Environmental Management Plan – Identification of Significant or Unacceptable Impacts – Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation – Stipulating the Conditions, Monitoring Methods – Pre- Appraisal and Appraisal.

UNIT V CASE STUDIES 9

Preparation of EIA for developmental projects – Factors to be considered in making assessment decisions – Water Resources Project – Pharmaceutical industry, thermal plant – Nuclear fuel complex. Highway project – Sewage treatment plant, Municipal Solid waste processing plant – **Successful and Unsuccessful EIA reports**

Contact Periods:

Lecture: 45 Periods Tutorial: 0 Periods Practical: 0 Periods Project 0 Periods

Total 45 Periods

TEXT BOOK:

1. Larry W Canter, “Environmental Impact Assessment” McGraw Hill, Inc, 2005.
2. Betty Bowers Marriot, “Environmental Impact Assessment” McGraw Hill, Inc, 2010.
3. Barrow, C. J., “Environmental and Social Impact Assessment” Edward Arnold, 2007.

REFERENCE BOOK:

1. Jain, R.K., Urban, L.V., Stracy, G.S., “Environmental Impact Analysis” Van Nostrand Reinhold Co., New York, 1991.
2. Rau, J.G. and Wooten, D.C., “Environmental Impact Assessment” McGraw Hill Pub. Co., 1996.

EVALUATION PATTERN:

Continuous Internal Assessments					
Assessment I (100 Marks)		**Assessment II (100 Marks)**		**Total Internal Assessments**	**End Semester Examinations**
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	**60**	**40**	**60**	**200**	**100**
Total				**40**	**60**
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided.

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SEMESTER IV

U21CEX01	ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT	Category: OEC				
		L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart the knowledge and skills to identify the environmental and social impacts of developmental projects
- To gain the knowledge in assessing and mitigate the environmental and social impacts of developmental projects
- To explain the various components for preparing the EIA document

COURSE OUTCOMES:

Upon the completion of the course the student will be able to

CO1: Illustrate the principles of EIA (Understand)

CO2: Infer the scope and screening of EIA developmental projects (Understand)

CO3: Plan environmental impact assessments and environmental management plans (Understand)

CO4: Evaluate Socio-economic reports of environmental impacts (Understand)

CO5: Outline the reports of EIA studies (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3	1	-	-	2	2	-	-	1	-	-		
CO2	1	3	1	-	-	2	2	-	-	1	-	-		
CO3	1	3	1	-	-	2	2	-	-	1	-	-		
CO4	1	3	1	-	-	2	2	-	-	1	2	-		
CO5	1	3	1	-	-	2	2	-	-	1	2	-		
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)						3: Substantial (High)				

SYLLABUS:

UNIT I INTRODUCTION 9

Impacts of development on environment – Rio Principles of sustainable development – Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle – EIA Notification and Legal Framework.

UNIT II ENVIRONMENTAL ASSESSMENT 9

Screening and scoping in EIA – Drafting of terms of reference, Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna – Matrices – Networks – Checklist

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Methods – Mathematical models for Impact prediction.

UNIT III ENVIRONMENTAL MANAGEMENT PLAN 9

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna – Environmental Monitoring Plan – EIA Report Preparation – Public Hearing – Environmental Clearance.

UNIT IV SOCIO ECONOMIC ASSESSMENT 9

Baseline monitoring of Socio-economic environment – Identification of project affected personal – Rehabilitation and resettlement plan – Economic valuation of environmental impacts – Cost benefit analysis.

UNIT V CASE STUDIES 9

EIA case studies pertaining to Infrastructure Projects – Roads and Bridges – Mass Rapid Transport Systems – Airports – Dams and Irrigation projects – Power plants.

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project – Periods

Total 45 Periods

TEXT BOOKS:

1. Canter, R.L, "Environmental Impact Assessment ",McGraw Hill Inc, 2nd Edition, New Delhi,1995.
2. Lohani, B., J.W. Evans, H. Ludwig, R.R. Everitt, Richard A. Carpenter, and S.L. Tu, "Environmental Impact Assessment for Developing Countries in Asia", Volume 1 – Overview, Asian Development Bank, 1st Edition,1997.
3. Peter Morris, Riki Therivel "Methods of Environmental Impact Assessment", Routledge Publishers, 2nd Edition, 2009.

REFERENCES:

1. Becker H. A., Frank Vanclay,"The International handbook of social impact assessment" conceptual and methodological advances, Edward Elgar Publishing, 3rd Edition, 2003.
2. Barry Sadler and Mary McCabe, "Environmental Impact Assessment Training Resource Manual", United Nations Environment Programme, 2nd Edition, 2002.
3. Judith Petts, "Handbook of Environmental Impact Assessment Vol. I and II", 1st edition, Blackwell Science New York, 1998.
4. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, New Delhi, 2010.

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SEMESTER IV

		Category: OEC				
U21CEX02	INTEGRATED WATER RESOURCE MANAGEMENT	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To impart the knowledge in the role of disciplines of ecology and socio-economics play in management of water resources
- To gain the knowledge in the global food security and public-private participation issues
- To explain the legal and regulatory settings in the context of integrated water resource management

COURSE OUTCOME:

Upon the completion of the course the student will be able to

CO1: Identify the key challenges and needs of integrated water resource management (Understand)

CO2: Explain the economic aspects of water issues (Understand)

CO3: Interpret the health protection and promotion in the context (Understand)

CO4: Find suitable water for food protection (Understand)

CO5: Formulate regulations of integrated water management system (Understand)

CO-PO MAPPING:

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	-	-	-	2	2	-	-	-	-	-	-	-
CO2	1	2	-	-	-	2	2	-	-	-	-	-	-	-
CO3	1	2	-	-	-	2	2	-	-	-	-	-	-	-
CO4	1	2	-	-	-	2	2	-	-	-	2	-	-	-
CO5	1	2	-	-	-	2	2	1	-	-	2	-	-	-
Correlation levels:	1: Slight (Low)			2: Moderate (Medium)					3: Substantial (High)					

SYLLABUS:

UNIT I CONTEXT FOR IWRM 9

Water as a global issue: key challenges and needs – Definition of IWRM within the broader context of development – Complexity of the IWRM process – Examining the key elements of IWRM process.

UNIT II WATER ECONOMICS 9

Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments, policy options for water conservation and sustainable use – Case studies.

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Civil Engineering,
KPR Institute of Engineering and Technology,
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UNIT III WATER SUPPLY AND HEALTH WITHIN THE IWRM CONSIDERATION 9

Links between water and human health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Health impact assessment of water resources development.

UNIT IV AGRICULTURE IN THE CONCEPT OF IWRM 9

Baseline monitoring of Socio-economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental Impacts – Cost benefit Analysis.

UNIT V WATER LEGAL AND REGULATORY SETTINGS 9

Basic notion of law and governance: principles of international and national law in the area of water management – Understanding UN law on non-navigable uses of international water courses – Development of IWRM in line with legal and regulatory framework.

Contact Periods:

Lecture: 45 Periods Tutorial: - Periods Practical: - Periods Project: - Periods

Total: 45 Periods

TEXT BOOKS:

1. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
2. Technical Advisory Committee, Poverty Reduction and IWRM, Technical Advisory Committee Background paper no: 8. Global water partnership, Stockholm, Sweden, 2003.
3. Technical Advisory Committee, Regulation and Private Participation in Water and Sanitation section, Technical Advisory Committee Background paper No:1. Global water partnership, Stockholm, Sweden, 1998.

REFERENCES:

1. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
2. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.
3. Technical Advisory Committee, Effective Water Governance "Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003. Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.
4. Mollinga.P. et.al "Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2nd Edition, 2006.

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DEPARTMENT OF CIVIL ENGINEERING

SEMESTER V

		Category: OEC				
U21CEX04	WASTE MANAGEMENT	L	T	P	J	C
		3	0	0	0	3

PRE–REQUISITES:

- Nil

COURSE OBJECTIVES:

- To understand the solid waste management, recent trends in global solid waste processing
- To demonstrate the recent technologies, in handling of the wastes such as hazardous, biomedical, electronic waste
- To explain the wastewater management and its treatment processes

COURSE OUTCOMES:

Upon completion of the course, the student will be able to

CO1: Demonstrate the municipal solid waste management (Understand)

CO2: Infer on hazardous waste management (Understand)

CO3: Outline on biomedical waste management (Understand)

CO4: Illustrate the management of E–waste (Understand)

CO5: Summarize the management on wastewater (Understand)

CO-PO MAPPING:

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

Correlation levels: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

SYLLABUS:

UNIT I MUNICIPAL SOLID WASTE MANAGEMENT 9

Municipal solid wastes – Introduction, sources and characteristics – Generation – Collection – Transport – Treatment – Disposal in landfills – Leachate – Solid waste impact on environment and human health – Recent trends in global solid waste processing technologies – Solid waste handling rules

UNIT II HAZARDOUS WASTES 9

Hazardous wastes – Introduction, sources and characteristics – Generation – Collection – Transport – Treatment and disposal – Legislation on management – Handling of hazardous wastes

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UNIT III BIOMEDICAL WASTE 9

Biomedical wastes – Introduction, Sources – Characterization – Types – Impact of biomedical waste on environment – Global scenario – Methods of treatment and disposal – Ethical aspects and legal implications

UNIT IV ELECTRONIC WASTE 9

Electronic wastes – Introduction, Sources – Characterization – Types – Impact of e–waste on environment – E-waste management – Control measures – Treatment and disposal system of e-waste

UNIT V WASTE WATER MANAGEMENT 9

Wastewater – Introduction, generation and characteristics – Effluent standards – Layout of sewage treatment plant – Sewage disposal – Sludge treatment and disposal – Recent advances

Contact Periods:

Lecture: 45 Periods Tutorial: – Periods Practical: – Periods Project: – Periods

Total: 45 Periods

TEXT BOOKS:

1. Gerard Kiely, "Environmental Engineering", 2nd edition, McGraw Hill Education (India) Pvt Ltd., 2013
2. Sincero A. P and Sincero G. A, "Environmental Engineering", 1st edition, A Design Approach by Prentice Hall of India, 2014

REFERENCES:

1. Garg. S. K, "Environmental Engineering (Vol.II) Sewage disposal and Air Pollution Engineering", 2nd edition, Khanna Publishers, 2008
2. Peavy. H. S, Rowe. D.R, and Tchobanoglous. G, "Environmental Engineering", 3rd edition, McGraw–Hill international edition, 1985
3. Simeon Dulo Solid, "Waste Management", 1st edition, VDM Verlag publication, 2010.

EVALUATION PATTERN:

Continuous Internal Assessments				Total Internal Assessments	End Semester Examinations
Assessment I (100 Marks)		Assessment II (100 Marks)			
*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test	*Individual Assignment / Case Study / Seminar / Project / MCQ	Written Test		
40	60	40	60	200	100
Total				40	60
				100	

*Role Play / Group Discussions / Debates / Oral Presentations / Poster Presentations / Technical presentations can also be provided. Course Designer can choose any one / two components based on the nature of the course.

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