SRM Institute of Science and Technology

(Deemed to be University u/s 3 of UGC Act, 1956)

College of Engineering and Technology

School of Bio Engineering

Department of Chemical Engineering

MINOR IN GREEN ENERGY AND ENVIRONMENTAL ENGINEERING

Foundation Courses (F)					
Course Code	Foundation Courses- Title	Hours/ Week			C
		L	T	P	
21MCH121F	Total Pollution Management	3	0	0	3
21MCH122F	Green Materials and Sustainable Technologies	3	0	0	3
21MCH123F	Circular Water Management	3	0	0	3
21MCH124F	Environmental Quality Monitoring and Analysis	3	0	0	3
	Total Learning Credits				**12**
Elective Courses (E)					
Course Code	Elective Courses-Title (Any 2)	Hours/ Week			C
		L	T	P	
21MCH221E	Energy Audit and Management	3	0	0	3
21MCH222E*	Smart Waste Management	3	0	0	3
21MCH223E	Carbon Capture Technologies	3	0	0	3
	Total Learning Credits				**6**

*** – Blended mode (online)**

Course Code	21MCH121F	Course Name	TOTAL POLLUTION MANAGEMENT	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand the importance of pollution control, source, types of atmospheric, soil and water pollutions and how its leads to the important global issues.
CLR-2 :	Gain knowledge in emerging contaminates, pollution control measures in various industries, and its prevention methods.
CLR-3 :	Acquire knowledge in source, standards of air, noise, water and odour pollutions, and its treatment techniques. to manage the pollutants.
CLR-4 :	Understand the source, types of solid waste management and its disposal methods. to manage municipal, medical, e - waste and nuclear waste.
CLR-5 :	Critically examine the environmental policy, legislation, environmental act and various environmental assessment.

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)											
		1	2	3	4	5	6	7	8	9	10	11	12
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
CO-1 :	Comprehend the source and types of atmospheric, soil and water pollution and how its leads to the important global issues.	*1*						*2*					
CO-2 :	Understand the emerging contamination, pollution control measures in various types of industries, and its prevention methods.		*2*					*2*					
CO-3 :	Implement the treatment techniques to control air, noise, water and odour pollutions.			*2*				*2*					
CO-4 :	Implement the treatment techniques to manage the municipal solid waste, medicinal waste, e waste, and nuclear waste.			*2*				*2*					
CO-5 :	Interpret environmental policies, legislation, environmental act and various environmental assessment at various level.						*2*	*2*					

Module 1:* Introduction, Classification, Global issues** ***9 Hours

Introduction to Pollution Control. Source and types of Atmospheric and Soil pollutions. Wastewater characteristics, Need of water treatment. Classification of air pollutants. Global issues: Greenhouse effect, Ozone depletion, Global warming, Acid rain.

Module 2:* Industrial Pollution Prevention** ***9 Hours

Emerging contaminates and pollution control measures for Chemical industries (Pulp, Paper, Sugar, Cement, Fertilizers, Petrochemical, etc). Zero discharge and cleaner production Technology. Environment friendly chemical processes. Improved process methods to reduce pollution.

Module 3:* Air, Noise and Odour Pollution** ***9 Hours

Source, Air quality standards and Quality index, sampling measurement and control methods. Air pollution control equipment's. Dust management. Noise pollution: Sources, causes, effects and control methods. Odor Control Systems.

Module 4:* Solid Waste Management** ***9 Hours

Sources, types and general disposal methods of solid waste, Waste disposal and management laws and guidelines, Value-extraction from the solid wastes, energy from solid waste. Processing methods: Municipal waste, Biomedical waste, E-waste, plastic waste and nuclear waste.

Module 5: **Environmental Policy, Legislations & Assessment**	***9 Hours***
National Environment Policy, International Conventions and Obligations, International treaties of Environment, Environmental Act & amendments, Rules and Notifications made under Environmental (Protection) Act. Environmental Impact analysis- Notification, Methodology, models, Environmental Monitoring and Management Plan, Public consultations	

Learning Resources	1. *Pandey.G.N and Carney.G.C, —Environmental Engineering‖, Tata McGraw Hill, New Delhi,2017.* 2. *Bishop.P, "Pollution Prevention: Fundamentals and Practice", McGraw Hill International Edn., McGraw Hill Book Co., Singapore, 2000.* 3. *Gilbert M. Masters, Wendell P. Ela, "Introduction to Environmental Engineering and Science", Pearson Education, 3rd Edition, 2007.* 4. *Thomas T. Shen," Industrial Pollution Prevention" Springer, 1995.* 5. *Noel de Nevers, "Air Pollution Control Engineering", McGraw-Hill Education, 3rd Edition, 2016.* 6. *Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, "Environmental Engineering", McGraw-Hill Education, 1st Edition, 1985.* 7. *Jerald L. Schnoor, "Environmental Modeling: Fate and Transport of Pollutants in Water, Air, and Soil", Wiley- Inter Science, First Edition, 1996.* 8. *Rajaram, V., Siddiqui, F.Z., Agrawal, S.,Khan, M.E., —Solid and Liquid Waste Management Waste to Wealth‖, PHI Learning Pvt Ltd, 2016.* 9. *Zafar Mahfooz Nomani, Environment Impact Assessment Laws, Satyam Law International, 1st Edition, 2022.* 10. *R.K.Khitoliya, "Environmental Legislation and Policy", Discovery Publishing House Pvt Ltd, 1st Edition, 2021*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*25%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	1. *Dr. K.Sofiya, SRM IST*
		2. Dr. K.Anbalagan, SRM IST

Course Code	21MCH122F	Course Name	GREEN MATERIALS AND SUSTAINABLE TECHNOLOGIES	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand global material consumption, waste generation, sustainability concepts, and the role of green materials in promoting environmental balance
CLR-2 :	Explore bio-based sustainable green materials, their sources, types, and applications
CLR-3 :	Familiarize the conversion of waste into valuable materials through various processing methods, supporting a circular economy.
CLR-4 :	Explore renewable energy systems, energy storage, and sustainable technologies for energy efficiency
CLR-5 :	Explore emerging trends in green materials, including biomimetics, nanotechnology, and closed-loop material systems, to shape future sustainable technologies

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Identify sustainability models, green materials characteristics, and their role in reducing environmental impact
CO-2 :	Comprehend the usage of bio-based materials such as biopolymers, natural fiber composites, and their real- world applications in various industries
CO-3 :	Appreciate the waste valorization techniques and how recycled materials are used in green composites and sustainable applications
CO-4 :	Comprehend sustainable energy materials used in solar cells, wind turbines, batteries, and hydrogen storage, and their impact on clean energy
CO-5 :	Analyze advanced green material innovations and their applications in various industries, with an emphasis on sustainability

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
3						2					
1						3					
				3		2					
1						3					
				1		3					

Module-1 - Introduction To Green Materials And Sustainability ***9 Hours***

Global scenario of materials consumption and waste generation, Carbon footprint, Cradle-to-Cradle vs Cradle-to-Grave models, Global policies and sustainability benchmarks, Sustainable Development Goals (SDGs), Green Materials - Definition and characteristics, Types of Green Materials, Green materials vs Conventional Materials

Module-2 – Bio-based Green Materials ***9 Hours***

Sources - Agriculture/Forestry, Marine, Microbial, Bio-composites, Natural fiber composites, Biopolymers and Bioplastics - Polylactic acid (PLA), Polyhydro oxyalkanoates (PHA), Polybutylene succinate (PBS), Green composites for the built environment, Case studies - PLA in food packaging, Hempcrete in sustainable construction, Natural fiber-reinforced plastics in automobiles

Module-3 – Waste-to-materials ***9 Hours***

Waste valorization, Types of waste used for production of materials - Industrial, Agricultural, Electronic wastes, Sorting and preprocessing of waste - Mechanical, Thermal, Chemical, and Biochemical methods, Applications as green composites, construction materials, and fuels, Environmental Impact Assessment of recycled/reclaimed waste

Module-4 - Materials for Sustainable Energy and Storage ***9 Hours***

Green materials for solar energy systems - Silicon-based vs thin-film photovoltaic materials, Perovskite solar cells, Green materials for wind turbines - Composite materials and coatings, Green batteries - Sodium ion battery, Lithium Iron Phosphate (LFP) battery, Solid-state electrolytes, Materials for hydrogen storage - Metal Organic Frameworks (MOFs), Materials for thermal energy storage - Phase change materials

Module-5 – Future Trends and Applications	***9 Hours***
Biomimetic Materials, Green Nanotechnology and Sustainable Nanomaterials, Carbon Capture Materials and CO_2-absorbing Composites, Closed loop Material Design, Green Materials for 3D Printing and Additive Manufacturing, Life Cycle Assessment and Eco-Design Tools, Market Trends in Green Materials, Careers in Sustainability	

Learning Resources	*1. Geiser, Ken. "Materials matter: Toward a sustainable materials policy." MIT press, 2001.* *2. Baillie, Caroline, and Randika Jayasinghe. "Green composites: natural and waste-based composites for a sustainable future." Woodhead Publishing Series in Composite Science and Engineering, 2017.* *3. Plackett, David, ed. "Biopolymers: new materials for sustainable films and coatings". John Wiley & Sons, 2011.* *4. Ashter, Syed Ali. "Introduction to bioplastics engineering". William Andrew, 2016.* *5. Stevens, Christian V. "Waste valorisation: waste streams in a circular economy." Wiley Series in Renewable Resources, 2020.* *6. Lin, Ming-Fa, and Wen-Dung Hsu, eds. "Green energy materials handbook". CRC Press, 2019.* *7. Van Wijk, A. J. M., and Iris van Wijk. 3D printing with biomaterials: Towards a sustainable and circular economy. IOS press, 2015.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	*1. Dr. K.Deepa, SRM IST*
		2. Dr. K.Anbalagan, SRM IST

Course Code	21MCH123F	Course Name	CIRCULAR WATER MANAGEMENT	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand the principles of the circular economy and how they can be applied to sustainable water management to reduce waste, promote reuse, and improve resource efficiency.
CLR-2 :	Gain technical knowledge of water treatment and reuse technologies, including both conventional and emerging methods, to design and evaluate efficient water systems.
CLR-3 :	Explore resource recovery and zero liquid discharge (ZLD) concepts to turn wastewater into a source of valuable products such as nutrients, energy, and clean water.
CLR-4 :	Apply circular economy principles to urban, industrial, and agricultural water systems using smart technologies and sustainable reuse solutions.
CLR-5 :	Critically examine policy frameworks, business models, and real-world case studies to understand how interdisciplinary approaches and stakeholder engagement contribute to circular water solutions in urban, industrial, and agricultural contexts.

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Understand and explain the principles of circular economy and their application in water management.
CO-2 :	Analyze various water treatment and reuse technologies in industrial and municipal settings.
CO-3 :	Analyze different methods for resource recovery and wealth generation from wastewater and apply the concepts of the 5R's in the context of water usage and wastewater treatment.
CO-4 :	Evaluate and apply circular economy strategies in urban, industrial, and agricultural water systems
CO-5 :	Interpret relevant policies, regulations, and standards associated with circular water management and evaluate case studies and models of circular water management across various sectors.

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
1						*2*					
	2		*3*								
		3				*2*					
		3				*2*					
					2		*2*				

Module-1 - Fundamentals of Circular Water Management ***9 Hours***

Concept of circular economy, Circular economy concepts in water management, Linear vs circular water systems, Overview of global and local water challenges, Global water scarcity and demand scenarios, Water footprint and life cycle assessment, Interdisciplinary approach to water sustainability, Stakeholders and governance in water management.

Module-2 – Water Treatment and Reuse Technologies ***9 Hours***

Primary, secondary, and tertiary treatment processes, Advanced oxidation, membrane processes, and nanotechnology, Decentralized vs centralized water treatment, Case studies in chemical and manufacturing industries.

Module-3 – Resource Recovery and Zero Liquid Discharge ***9 Hours***

Wastewater as a resource: nutrients, biogas, clean water - Anaerobic digestion, membrane technologies, and sludge valorization - Energy generation from wastewater: microbial fuel cells, bioenergy, Water-energy-food nexus, 5R principles in water management, Water recycling and cascading use, Closed-loop systems in industries, Zero Liquid Discharge (ZLD): concepts, technologies, and challenges.

Module-4 - Circular Economy Applications in Water Sector ***9 Hours***

Integration of circular economy in water utilities, Urban mining from water systems, Water-sensitive urban design (WSUD) and smart cities, Urban water reuse: greywater and blackwater treatment, Sustainable urban drainage systems (SUDS), Smart water grids and metering, Circular innovations in agriculture (e.g., fertigation with treated water), Agricultural runoff management and reuse.
Module-5 –Policies, Frameworks, Regulations, Circular Economy Models and Case Studies ***9 Hours*** *Water policies: National and International frameworks, International and national policies on circular water management, Indian standards and water quality regulations, Role of SDGs (especially SDG 6, 11, and 12), Circular business models and stakeholder engagement, Case studies of successful circular water initiatives, Emerging technologies and future trends.*

Learning Resources	1. *Metcalf & Eddy, Tchobanoglous G., Burton F. L., and Stensel H. D.,* "Water Reuse: Issues, Technologies, and Applications," *McGraw-Hill, 1st Edition, 2006.* 2. *Metcalf & Eddy, Tchobanoglous G., Stensel H. D., and Tsuchihashi R.,* "Wastewater Engineering: Treatment and Resource Recovery," *McGraw-Hill, 5th Edition, 2014.* 3. *Peavy H. S., Rowe D. R., and Tchobanoglous G.,* "Environmental Engineering," *McGraw-Hill, 1st Edition, 1985.* 4. *Singh, A. K., "Smart Water Management Technologies," Narosa Publishing House, 1st Edition, 2017.* 5. *Rajiv K. Sinha, "Sustainable Wastewater Management for Developing Countries," Concept Publishing Company, 2012.* 6. *CSE (Centre for Science and Environment), "Urban Water and Waste Management in India,"CSE Publication, 2012.* 7. *UNEP Report on Circular Water Economy https://unepdhi.org/wp-content/uploads/sites/2/2024/03/FB-033-Final-080224.pdf* 8. *BIS and ISO standards on water and wastewater https://cpcb.nic.in/wqm/BIS_Drinking_Water_Specification.pdf* 9. *NITI Aayog Reports on Water Management Index and Reuse Policies, https://www.niti.gov.in/sites/default/files/2023-03/CompositeWaterManagementIndex.pdf* 10. *MoEF&CC Guidelines on water reuse, industrial effluent management, and circular economy models https://mohua.gov.in/pdf/627b8318adf18Circular-Economy-in-waste-management-FINAL.pdf https://cpcb.nic.in/openpdffile.php?id=TmV3c0ZpbGVzLzEwNV8xNzA3Mzc4MTYwX21lZGlhcGhvdG8yMDUzNC5wZGY*

Learning Assessment

	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*25%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	1. *Dr. E. Poonguzhali, SRM IST*
		2. *Dr. K.Anbalagan, SRM IST*

Course Code	21MCH124F	Course Name	ENVIRONMENTAL QUALITY MONITORING AND ANALYSIS	Course Category	F	Foundation	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Learn about environmental systems, pollution types, and related regulations
CLR-2 :	Understand how to collect and handle air, water, and soil samples
CLR-3 :	Learn to use instruments and methods to test environmental quality
CLR-4 :	Understand how to analyze environmental data and predict pollutant spread
CLR-5 :	Explore how AI and IoT are used in smart environmental monitoring

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Describe environmental systems, pollution types, and regulatory frameworks
CO-2 :	Apply appropriate sampling techniques for air, water, and soil in environmental assessments
CO-3 :	Analyze environmental samples using standard instrumentation and quality parameters
CO-4 :	Interpret environmental data and model pollutant transport and dispersion
CO-5 :	Demonstrate the use of AI and IoT in real-time environmental monitoring with practical examples

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
						3					*2*
	2					*3*					
	1					*2*					
	2		*3*								
				3		*1*					

Module 1:* Environmental Pollution and Regulatory Frameworks** ***9 Hours

Basics of environmental systems (air, water, soil, biosphere); Types and sources of pollution (air, water, soil, noise); Source → Environment → Receptor pathway; Exposure, health effects, and environmental toxicology; Global and local environmental issues; Environmental standards: World Health Organization (WHO), Environmental Protection Agency (EPA), Central Pollution Control Board (CPCB), Bureau of Indian Standardas (BIS).

Module 2:* Sampling Techniques** ***9 Hours

Sampling protocols for air, water, and soil; Site selection, frequency, and duration; Preservation and storage of samples; Introduction to field kits and portable devices.

Module 3: Instrumentation and Analysis ***9 Hours***

Principles of environmental instrumentation; Spectrophotometry, Chromatography, Gravimetric and titrimetric methods. Water quality analysis: pH, Total dissolved solid (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), nitrates, phosphates. Air quality analysis: Particulate Matter (PM2.5, PM10), SOx, NOx, Carbon monoxide (CO), Ozone. Soil quality analysis: heavy metals, pH, Electrical conductivity

Module 4:* Data Interpretation, Transport and Dispersion Models** ***9 Hours

Statistical analysis of environmental data (mean, SD, regression), Trend analysis and anomaly detection, Air Quality Index (AQI), Water Quality Index (WQI), Box models for environmental transport, Gaussian plume model, Multiple cell model

Module 5: Intelligent Environmental Monitoring ***9 Hours***

Artificial Intelligence (AI) in environmental monitoring, Use of AI for analyzing air and water quality, Real-time monitoring with AI and IoT, Simple case studies and real-world examples, Future trends in smart environmental monitoring systems

Learning Resources	1. *Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, "Environmental Engineering", McGraw-Hill Education, 1st Edition, 1985.* 2. *Gilbert M. Masters, Wendell P. Ela, "Introduction to Environmental Engineering and Science", Pearson Education, 3rd Edition, 2007.* 3. *Maria Csuros, "Environmental Sampling and Analysis: A Practical Guide", CRC Press, 1st Edition, 1998.* 4. *S.P. Mahajan, "Air Quality Monitoring and Control Strategy", Khanna Publishers, 1st Edition, 2006.* 5. *Douglas A. Skoog, F. James Holler, Stanley R. Crouch, "Principles of Instrumental Analysis", Cengage Learning, 6th Edition, 2006.* 6. *A.K. De, "Environmental Chemistry", New Age International Publishers, 7th Edition, 2008.* 7. *Jerald L. Schnoor, "Environmental Modeling: Fate and Transport of Pollutants in Water, Air, and Soil", Wiley-Interscience, 1st Edition, 1996.* 8. *Noel de Nevers, "Air Pollution Control Engineering", McGraw-Hill Education, 3rd Edition, 2016.* 9. *Mohsen Asadnia, Amir Razmjou, Amin Beheshti, "Artificial Intelligence and Data Science in Environmental Sensing," Academic Press, 2022.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*25%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*		*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	1. *Dr. S.Vishali, SRM IST*
		2. *Dr. K.Anbalagan, SRM IST*

Course Code	21MCH221E	Course Name	ENERGY AUDIT AND MANAGEMENT	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Study the concepts behind energy audit and conservation.
CLR-2 :	Understand the basics of financial and role of managers.
CLR-3 :	Analyze the energy efficiency in thermal utilities.
CLR-4 :	Know the concept of electrical utilities.
CLR-5 :	Illustrate the concept of energy management in building.

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Acquire knowledge in the field of energy management and auditing process.
CO-2 :	Learn the basic concepts of economic analysis and load management.
CO-3 :	Design the effective thermal utility system.
CO-4 :	Improve the efficiency in electric system.
CO-5 :	Design concepts in the field of lighting systems, light sources, building energy management.

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
1										*2*	
		1								*2*	
3		*2*									
3		*1*									
		3								*2*	

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Module 1: Energy Audit and Conservation **9 Hours**

Energy needs, Energy monitoring, Energy Systems, Energy Economics, Energy Consumption, Energy Pricing, Energy Conservation, Energy Conservation Act 2001, Energy Conservation (Amendment) Act, 2010 and its features, Electricity Tariff, Schemes of Bureau of Energy Efficiency (BEE), Need and Types of Energy Audit, Energy audit approach, Instruments and metering for energy audit, energy management motivation - Case study

Module 2: Financial Evaluation and Policy Planning in Energy Management **9 Hours**

Simple Payback Period, Return on Investment, Net Present Value, Internal Rate of Return, Time Value of Money, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated - Energy policy and planning - roles and responsibilities of energy manager – employees training and planning- Financial Management: financial analysis technique.

Module 3: Energy Efficiency In Thermal Utilities **9 Hours**

Steam engineering, Boilers, Steam traps and various Energy Conservation Measures in Steam, Energy conservation opportunities in boilers, Compressed Air System, Refrigeration & Air conditioning, Heat load estimation, Energy conservation in cooling towers, spray ponds, Cogeneration - Case Study

Module 4: Energy efficiency in Electrical Utilities **9 Hours**

Electrical Load Management, Automatic Power Factor Controllers, Electric motors: Types, factors affecting motor performance, energy saving opportunities with energy efficient motors, Fans: Types, Performance Evaluation, Energy saving opportunities, Pumps :Types, Efficient Pumping system operation, Lighting System: Light source, Energy Efficient Lighting Controls, Energy Saving Opportunities, Case Study.

Module 5: Building Energy Standards And Optimization **9 Hours**

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

Learning Resources	1. *Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists, Logman Scientific & Technical, ISBN-0-582-03184, 1990.* 2. *Guide Books for National Certification Examination for Energy Managers and Energy Auditors – BEE (India)* 3. *Moncef Krarti, "Energy Audit of Building Systems: An Engineering Approach", Third Edition, CRC Press, 2020* 4. *Michael P. Deru, Jim Kelsey, "Procedures for Commercial Building Energy Audits", Second Edition, American Society of Heating, Refrigerating and Air-conditioning Engineers, 2011* 5. *Daniel Martinez, Ben W. Ebenhack, Travis Wagner, "Energy Efficiency Concepts and Calculations", First Edition, Elsevier Science, 2019* 6. *Mehmet Kanoglu, Yunus A Cengel, "Energy Efficiency and Management for Engineers", McGraw-Hill Education, First Edition, 2020.* 7. *'Energy Managers and Energy Auditors Guide book', Bureau of Energy Efficiency, 2006.* 8. *B K De, Energy Management, Audit and Conservation, 2nd Edition, Vrinda Publications Private LTD-Delhi, 2014*

Learning Assessment

	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*25%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	*Dr. S. Sundaramoorthy, Professor, Puducherry Technological University*	1. *Dr. K.Anbalagan, SRM IST*
		2. *Dr.S.Vishali, SRM IST*

Course Code	21MCH222E	Course Name	SMART WASTE MANAGEMENT	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Understand the fundamentals of waste types, principles of waste management and sustainability frameworks
CLR-2 :	Explore modern technologies in waste collection, sorting, and recycling
CLR-3 :	Learn the application of IoT and data-driven technologies in waste monitoring and management
CLR-4 :	Examine various technologies and methods used for recovering energy and valuables from waste
CLR-5 :	Discover entrepreneurial opportunities and innovative practices in waste management

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Identify types of waste and analyze the impact of improper waste management
CO-2 :	Compare traditional and smart waste systems, and evaluate recycling techniques
CO-3 :	Apply sensor technologies and data analytics to develop smart solutions
CO-4 :	Analyze value recovery techniques and extraction from solid and liquid wastes
CO-5 :	Design business models and evaluate innovations in smart waste management

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
						3					*2*
	3					*2*					
		1		*3*							
	1	*3*									
		1				*3*					

Module 1: Introduction to Waste Management and Sustainability ***9 Hours***

Introduction to all types of waste (gaseous, liquid, solids), Overview of waste management principles-4R's, Significance of waste management, Sustainable Development Goals (SDGs), Environmental and social impacts of improper waste management, National and International policies and regulations, Stakeholders in waste management: government, industry, public.

Module 2: Smart Waste Collection, Sorting and Recycling Systems ***9 Hours***

Traditional vs. smart collection systems, Smart bins, IoT for route optimization and real-time tracking. Technologies in automated sorting: Optical and infrared sorting, Magnetic separation, Robotic sorting using AI and ML. Recycling techniques for plastic, paper, metals, e-waste, and organic waste, Integration of MRFs (Material Recovery Facilities). Case study on recycling initiatives.

Module 3: Smart Technologies in Waste Management ***9 Hours***

Overview of IoT architecture for smart waste management; Sensor types: ultrasonic, IR, temperature, gas sensors; Data acquisition, cloud integration, and dashboard visualization; Predictive analytics for waste generation trends; Alert systems and automated actions

Module 4: Value Recovery ***9 Hours***

Introduction to Environmental impacts of waste to energy conversion, Technologies involved in the energy recovery from waste. Thermal analysis by pinch technology, Principles of composting and organic waste management. Recovery of valuables from solid waste and wastewater. Case Study on Recovery of valuables from the pharmaceutical industry

Module 5: Innovation, Entrepreneurship, and Case Studies in Smart Waste ***9 Hours***

Indian waste management market size, Opportunities in Indian waste market, Design thinking and ideation for waste-related problems, Innovative technologies and global startups in smart waste, Business models, Circular economy, Smart city initiatives in India, Environmental entrepreneurship: funding, incubation, and pitching. Case study on Indore waste management model.

Learning Resources	**Textbooks:** 1. *Morton, Leopold. "Smart Waste Management: Harnessing Technology for a Sustainable Tomorrow." Leopold Morton, 1st Edition, 2024.* 2. *Pichtel, John. "Waste Management Practices: Municipal, Hazardous, and Industrial." CRC Press, 2nd Edition, 2014.* 3. *Ejaz, Waleed; Anbalagan, Anumohan. "Internet of Things for Smart Cities: Technologies, Big Data and Security." Springer, 1st Edition, 2018.* 4. *Sasikumar, K.; Gopi Krishna, Sanoop. "Solid Waste Management." PHI Learning, 1st Edition, 2009.* 5. *Bhatia, S.C. "Environmental Pollution and Control in Chemical Process Industries." Khanna Publishers, 1st Edition, 2001.* 6. *Bhatia, S.C. "Wealth from Waste." Atlantic Publishers, 1st Edition, 2007.* 7. *Bishop, Paul L. "Pollution Prevention: Fundamentals and Practice." McGraw-Hill Education, 1st Edition, 2000.* 8. *Acharya, Biswaranjan; Dey, Satarupa; Zidan, Mohammed. "IoT-Based Smart Waste Management for Environmental Sustainability." CRC Press, 1st Edition, 2022.* ***Internet Sources*** *1. https://www.link-labs.com/* *2. https://www.infosys.com/industries/waste-management/industry-offerings/smart-collection-disposal.html* *3. https://www.greencitytimes.com/5-modern-waste-management-technologies/* *4. https://solarimpulse.com/waste-management-solutions* ***Research Articles*** *1. A Review on Smart Waste Collection and Disposal System, doi:10.1088/1742-6596/1969/1/012029* *2. Modern Technologies for Waste Management: A Review, doi.org/10.3390/app13158847* 3. *Smart waste management practices in smart cities: Current trends and future perspectives, doi.org/10.1016/B978-0-323-85792-5.00011-3*

Learning Assessment

	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*25%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	Dr. S. Sundaramoorthy, Professor, Puducherry Technological University	*1. Dr.S.Vishali, SRM IST*
		2. Dr. K.Anbalagan, SRM IST

Course Code	21MCH223E	Course Name	CARBON CAPTURE TECHNOLOGIES	Course Category	E	Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	
Course Offering Department	*Chemical Engineering*	Data Book / Codes/Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	Provide an understanding of the relationship between CO_2 emissions and climate change, and introduce the concept of carbon capture and storage (CCS)
CLR-2 :	Familiarize the methods of carbon capture in power generation and industrial processes
CLR-3 :	Explore the principles and applications of physicochemical technologies for CO_2 capture
CLR-4 :	Familiarize thermo-physical and geochemical methods for CO_2 capture
CLR-5 :	Familiarize the economic aspects of CCS, including regulations, financing, and the cost of the CCS chain

Course Outcomes (CO):	*At the end of this course, learners will be able to:*
CO-1 :	Understand the sources, sinks, and formation pathways of CO_2, and the basics of carbon capture and storage systems
CO-2 :	Investigate the methods of carbon capture in power generation and industrial processes, focusing on strategies for reducing CO_2 emissions
CO-3 :	Appreciate the absorption, adsorption, and membrane-based CO_2 capture systems and their applications
CO-4 :	Analyze thermo-physical (cryogenic, distillation, and mineral carbonation methods) and geochemical CO_2 sequestration
CO-5 :	Evaluate the economic feasibility of CCS technologies, considering regulatory frameworks, cost structures, and environmental impacts

Program Outcomes (PO)											
1	2	3	4	5	6	7	8	9	10	11	12
Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning
3						1					
			1			3					
			2			3					
			2			3					
						1				3	

Module-1 - Introduction to Carbon Capture and Climate Change ***9 Hours***

Relationship Between CO_2 and Climate, CO_2 Sources and Sinks - Chemical processes, Exhaust emissions, CO_2 usage and sinks, Formation Pathways of CO_2 - Coal oxidation, Coal-to-electricity conversion, liquid fuel and natural gas oxidation, Overview of carbon capture and storage, Cost of CO_2 capture

Module-2 - Carbon Capture from Power Generation and Industrial Processes ***9 Hours***

Carbon capture from power generation - Precombustion capture, Postcombustion capture, Oxyfuel combustion capture, Approaches to zero-emission power generation, Carbon capture from industrial processes - Cement production, Steel production, Oil refining, Natural gas processing

Module-3 - Physicochemical Carbon Capture Technologies ***9 Hours***

Fundamentals and applications of absorption and adsorption capture systems, Membrane separation systems - Fundamentals, Membrane configuration and module construction, Membrane applications in precombustion capture, oxyfuel combustion, postcombustion CO_2 separation, and natural gas processing

Module-4 - Thermo-physical and Geochemical CO_2 Capture Methods ***9 Hours***

Cryogenic and distillation systems - Distillation column configuration and operation, Cryogenic oxygen production for oxyfuel combustion, Ryan–Holmes process for CO_2–CH_4 separation, Mineral Carbonation, Geological storage - Enhanced oil recovery, Saline aquifer storage, Chemical and Biological Sequestration

Module-5 - Economics of Carbon Capture and Storage (CCS) ***9 Hours***

CCS Regulatory Framework, Emissions mitigation policies, CCS regulations, Obtaining an adequate price for CO_2, Cost of the CCS chain, CCS Economy, CCS projects financing, Social and environmental standpoints on CCS

Learning Resources	1. *Wilcox, Jennifer. "Carbon capture". Springer Science & Business Media, 2012.* 2. *Rackley, Steve A. "Carbon capture and storage". Butterworth-Heinemann, 2017.* 3. *Al-Fattah, Saud M., Murad F. Barghouty, and Bashir O. Dabbousi. "Carbon capture and storage: Technologies, policies, economics, and implementation strategies". CRC press, 2011.*

Learning Assessment							
	Bloom's Level of Thinking	***Continuous Learning Assessment (CLA) - By the Course Faculty***				***By The CoE***	
		Formative *CLA-I Average of unit test (50%)*		***Life Long Learning*** *CLA-II- Practice (10%)*		***Summative*** *Final Examination (40% weightage)*	
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
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Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*		-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Motcha Pradha , Director, Jwala Risk Consulting	Dr. S. Sundaramoorthy, Professor, Puducherry Technological University	1. *Dr. K. Deepa, SRM IST*
		2. *Dr. K. Anbalagan, SRM IST*