GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030041

Course/ Subject Name: Air Pollution Control System and Design

w.e.f. Academic Year:	A.Y. 2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basic knowledge of environmental engineering, thermodynamics, fluid mechanics, and heat transfer principles. Familiarity with chemical reaction engineering and pollution control concepts is recommended.
Rationale:	Air pollution control is crucial for mitigating environmental and health impacts. This course equips students with the knowledge and skills required to design, evaluate, and optimize systems for controlling particulate and gaseous pollutants. It prepares postgraduate students to address current and emerging air quality challenges in industrial and urban settings. Understanding control technologies, regulatory frameworks, and monitoring techniques will enable students to develop efficient and sustainable solutions in the field of environmental engineering.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	Analyze air pollution sources, effects, and regulatory standards.
02	Design and evaluate control technologies for particulate and gaseous pollutants.
03	Conduct sampling and analysis of air pollutants.
04	Assess and optimize air pollution control systems for multi-pollutant removal

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1	**Introduction to Air Pollution and its Effects:** Air pollution in India and the world, sources and classification of air pollutants, Air Quality Standards and Regulations, Health and Environmental Effects of Air Pollution,	04	9
2	**Meteorological Aspects of Air Pollution:** Temperature lapse rates and stability, meteorological factors influencing air pollution, plume behavior, dispersion of air pollutants and estimation of plume rise.	04	9
3	**Control Technologies for Particulate Matter:** Mechanical Collectors: Cyclones, settling chambers, and scrubbers, Electrostatic Precipitators (ESP): Design, operation, and Efficiency, Bag Filters: Types of filters, performance, and applications, Wet Scrubbers for Particulate Removal: Design considerations and selection criteria.	08	18
4	**Control Technologies for Gaseous Pollutants** Absorption Systems: Scrubbers, packed columns, and design considerations, Adsorption Systems: Activated carbon, design parameters, and efficiency, Catalytic and Thermal Oxidation: Principles of incineration, catalytic oxidation, and thermal oxidizers, Biofiltration and Bioreactors: Biological treatment of air pollutants.	08	18
5	**Sampling and Measurement of Air Pollution:** Types of pollutant sampling and measurement, ambient air sampling, stack sampling, analysis of air pollutants.	06	13
6	**Air Pollution Control Principles and System Design:** Basic Principles: Source control vs. end-of-pipe control, Flow Properties: Dispersion, deposition, and diffusion of gaseous pollutants. Pollutant Collection: Particle collection principles (size distribution, velocity, etc.)., Thermodynamics: Adsorption, absorption, condensation processes, Design Parameters: Flow rate, temperature, pressure, and pollutant concentration, Control System Design: Wet Scrubbers: Absorber size and liquid-to-gas ratio .Electrostatic Precipitators and Bag Filters: Sizing and performance. Adsorption and Absorption Units: Material selection, bed size, pressure drop, and mass transfer.	10	22

7	**Case Studies and Applications:** Industrial Applications: Air pollution control in chemical plants, refineries, and power plants etc., Emerging Technologies: Nanotechnology, membrane filtration, and catalytic materials, Recent Advances: Innovative air pollution control approaches and energy recovery, Maintenance and Troubleshooting: Common issues and solutions in air pollution control systems	05	11
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
11	18	21	14	3	3

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Air Pollution Control Engineering by Noel de Nevers, McGraw-Hill Education.
2. Introduction to Air Pollution by P. Aarne Vesilind and William A. W. Stokes, Prentice Hall.
3. Air Pollution Control: A Design Approach by C. David Cooper and F. C. Alley, Waveland Press.
4. Air Pollution Control: A Practical Guide by Sanjay K. Gupta, Butterworth-Heinemann.
5. Fundamentals of Air Pollution by Richard W. Boubel, Donald L. Fox, D. Bruce Turner, and Arthur C. Stern, Academic Press.
6. Air Pollution Control Equipment Calculations by Theodore L., John Wiley & Sons Inc., New Jersey.
7. Air Pollution Meteorology and Dispersion by S. P. Arya, Oxford University Press.
8. Air Pollution by H.C. Perkins, McGraw-Hill Kogakusha, Tokyo.
9. Fundamentals of Air Pollution" by Richard C. Flagan and John H. Seinfeld.
10. Air Pollutionby M.N. Rao, H.V.N. Rao, Tata McGraw Hill.

Open source software

OpenFOAM: OpenFOAM is an open-source software used for computational fluid dynamics (CFD) simulations, ideal for modeling air pollution dispersion and airflow patterns. It helps simulate pollutant behavior and plume dispersion under various atmospheric conditions.

SimScale: SimScale is a cloud-based simulation software offering tools for simulating environmental processes such as air pollution dispersion, thermal flow, and air quality monitoring

Website:

- United States Environmental Protection Agency (EPA)
- World Health Organization (WHO)
- Air Pollution Control Association (APCA)

Suggested Course Practical List: NA

1. To measure ambient air pollutants such as particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon monoxide (CO) using air quality monitoring instruments
2. To calculate and visualize the dispersion of air pollutants and estimate plume rise using meteorological data.
3. To evaluate the performance of an Electrostatic Precipitator (ESP) for particulate removal by measuring the efficiency of particle collection.
4. To design and test a cyclone separator for the removal of coarse particulates from an airstream.
5. To evaluate the collection efficiency of different types of bag filters for particulate removal from air streams.
6. To study the absorption of gaseous pollutants (e.g., CO_2 or SO_2) in a packed column scrubber.
7. To investigate the adsorption capacity of activated carbon for removing volatile organic compounds (VOCs) from air.
8. To design and optimize a wet scrubber for the removal of particulate and gaseous pollutants from air streams, considering parameters like liquid-to-gas ratio and absorber size.
9. To measure the concentration of pollutants such as CO_2, NO_x, and SO_2 in stack gases from industrial sources.
10. To conduct a case study on an industrial plant (e.g., chemical plant or power plant) for air pollution control systems, including identifying control technologies and assessing their performance.

List of Laboratory/ Learning Resources Required:

Air Quality Monitoring Instruments: Particulate Matter (PM_{10}, $PM_{2.5}$) analyzers, Sulfur Dioxide (SO_2) analyzers, Nitrogen Oxides (NO_x) analyzers, Carbon Monoxide (CO) analyzers, Ozone (O_3) analyzers, Gas

sampling pumps and collection bags, Electrostatic Precipitator (ESP) Setup, Cyclone Separator System, Bag Filter System, Packed Column Scrubber Setup, Packed Column Scrubber Setup, Wet Scrubber Setup, Stack Sampling and Measurement Equipment: Stack sampling probes, Gas analyzers (CO_2, NO_x, SO_2), Data logging devices, Condensing apparatus for moisture removal

Suggested Project List:

- Design and Performance Evaluation of a Cyclone Separator
- Development of a Wet Scrubber for Industrial Emissions
- Study of Adsorption Efficiency Using Activated Carbon for VOCs
- Modeling and Simulation of Air Pollution Dispersion Using AERMOD
- Design and Optimization of an Electrostatic Precipitator (ESP)
- Air Quality Monitoring in Industrial Zones: A Case Study
- Performance Evaluation of a Bag Filter System for Dust Removal
- Analysis of Catalytic Oxidation for Gaseous Pollutant Removal
- Design of a Packed Column Scrubber for Acid Gas Removal
- Investigation of Emerging Air Pollution Control Technologies

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