



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Environmental Engineering

Subject Code: BE05013021

Subject Name: Advanced Environmental Instrumentation

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Basic knowledge of environmental chemistry, water and wastewater quality parameters, Fundamentals of Air pollution and analytical methods.
Rationale:	To provide students with knowledge of advanced analytical instruments, sensor-based monitoring systems, and online environmental monitoring techniques for analysis of water, wastewater, and air quality parameters. The subject helps students to understand the principles, components, and applications of modern environmental instrumentation for real-time monitoring, process control, and environmental compliance.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Identify the basic components, calibration methods and automation systems used in environmental instrumentation.	10
CO-2	Demonstrate the application of spectroscopic instruments used for environmental analysis.	25
CO-3	Explain the principles and applications of chromatographic techniques for environmental analysis.	20
CO-4	Demonstrate the application of ion selective electrodes, dissolved oxygen meters, and TOC analyzers used for environmental monitoring.	10
CO-5	Illustrate the use of sensor-based instruments for quantity and quality monitoring of water, wastewater and air quality.	25

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	SL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/CA (I)	TW/SL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200



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Content:

Sr. No.	Content	Total Hrs
1	Basics of Environmental Instrumentation Need of Environmental Instrumentation, Classification of analytical instruments, Significance of instruments Calibration and standardization, Automation in environmental monitoring system	5
2	Spectroscopic Methods of Analysis: Electromagnetic spectrum, Principles, components and working of UV-Visible spectrophotometry, Infrared Spectroscopy (FTIR), Flame Emission Spectroscopy, Atomic Absorption Spectroscopy (AAS), Mass spectroscopy and Inductively Coupled Plasma (ICP) for trace heavy metals, and portable/field spectrometers. Applications of Spectroscopic Methods of Analysis in environmental engineering	12
3	Chromatographic Techniques: Classification of Chromatography, terminologies related to Chromatography, Principles, components, working and applications of Column Chromatography, Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Ion Chromatography. Applications of chromatography in environmental engineering	10
4	Miscellaneous Methods : Principles, components and working of Ion selective meter and electrodes, Dissolved oxygen meter, TOC analyzer	5
5	Sensor based Water and Wastewater Monitoring Systems Merits of on-line monitoring techniques, Basic requirements, instrumentation for online and inline measurements: Photometric Optical Technology Ion Selective Electrodes (ISE) Technology, Potentiometric Technology, Nephelometric Technology, Voltammetry, Total Organic Carbon (TOC) Based Technology, Flow Meters Introduction to biosensors and applications in monitoring water and wastewater quality parameters. Applications of online monitoring, advantages, limitations, calibration, and maintenance requirements of sensor-based water and wastewater monitoring systems.	7
6	Sensor based Air quality Monitoring Systems Parameters for ambient air: Principle, components and working of sensor-based measurement of Sulphur Dioxide, Particulate Matter, Carbon Monoxide, Oxides of Nitrogen, Ozone, Flow Monitoring Techniques Process parameters for stack: Principle, components and working of sensor-based measurement of Sulphur Dioxide, Particulate Matter Carbon Monoxide,	6



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Temperature, Pressure, Flow, Moisture Content, Oxygen, Carbon dioxide. Applications, advantages, limitations, calibration, and maintenance requirements of sensor-based Real-Time monitoring system	
TOTAL	45

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	40	20	00	00	00

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

The syllabus of Environmental Instrumentation & online Monitoring

SDG 6	Clean Water and Sanitation: The subject supports sustainable water and wastewater management through advanced environmental monitoring and online water quality assessment systems.
SDG 9	Industry, Innovation and Infrastructure: The subject promotes development of smart environmental monitoring infrastructure using modern analytical instruments, sensors, and automation technologies.
SDG 11	Sustainable Cities and Communities: The subject contributes to sustainable urban environmental management through continuous monitoring of water and pollution control systems.
SGD 13	Climate Action: The subject supports environmental data collection and pollution monitoring systems useful for climate-related environmental management and mitigation strategies.

Reference Books:

1. Chemical Sensors and Biosensors: Fundamentals and Applications: [Florinel-gabriel Banica](#)
2. Instrumental Methods of Analysis: B. Sivasankar
3. Principles of Instrumental Analysis: Douglas A. Skoog, F. James Holler, Stanley R. Crouch



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4. Environmental Instrumentation and Analysis Handbook: Jay H. Lehr, Randy D. Down.
5. Air Pollution Monitoring and Control Strategy: S. P. Mahajan
6. Meteorological Measurement Systems: Fred V. Brock, Scott J. Richardson
7. Urban Air Quality Monitoring, Modelling and Human Exposure Assessment: S. M. Shiva Nagendra, Uwe Schlink, Andrea Müller, Mukesh Khare

List of Experiments:

1. UV-Vis spectrophotometric analysis (fluoride/chromium)
2. Heavy metal analysis using Flame photometer/AAS/ICP (demo/virtual if unavailable)
3. Chromatographic separation using HPLC/GC (demo-based)
4. TOC analysis of wastewater (demo/virtual if unavailable)
5. Measurement of DO using probe method
6. Water quality monitoring using sensors (demo/virtual if unavailable)
7. Air quality monitoring using sensors (demo/virtual if unavailable)
8. Measurement of stack parameters using sensors (demo/virtual if unavailable)

Major Equipment:

pH meter
UV-Vis Spectrophotometer
Flame photometer
TOC Analyzer
Ion selective meter and electrodes
DO meter
Air quality monitoring sensors based system
Online stack monitoring system

List of Open Source Software/learning website:

1. CPCB Online Monitoring Portal: <https://cems.cpcb.gov.in/#/p/login>
2. NPTEL: [Environmental Quality Monitoring & Analysis | SWAYAM](https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch40) https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ch40,
3. [Infrared spectroscopy for pollution monitoring | SWAYAM](https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ch23) https://onlinecourses.nptel.ac.in/e-learning/preview/noc20_ch23
4. Analytical Chemistry: https://onlinecourses-archive.nptel.ac.in/noc17_cy03/preview
5. Molecular Absorption Spectroscopy: [Welcome to Virtual Labs](#)



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List of suggested activities for Term Work / Self Learning:

Sr. No.	PBL Category	Name of the Activity	No. of Hours	Evaluation Criteria
1	Seminar	Based on give technical topics beyond syllabus	Total = 10 hrs	Based on technical content, visual presentation, and explanation clarity
2	Research Laboratory Visit	Visit to environmental testing laboratory / water treatment plant to study analytical instruments and monitoring systems	Visit = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on report submitted. Report should include observations on instruments, monitoring parameters, and operational data interpretation
3	Video Based Learning	Technical video-based learning (NPTEL/MOOC) on spectroscopic instruments, chromatography, sensors, and online monitoring systems	Total = 10 hrs	MCQ test
4	Assignment / Technical Writing	Assignment on instrument selection, calibration methods, and environmental sample analysis (numerical/problem-based preferred)	5 assignments $\times$ 2 hrs Total = 10 hrs	Based on technical correctness, calculations, and interpretation
5	Research Paper Review / Analysis	Review research papers on biosensors, electrochemical sensors, online monitoring, or smart environmental monitoring systems	5 papers = 20 hrs	Summarization, critical analysis, identification of research gaps
6	Poster / Chart Presentation	Prepare poster/chart on environmental sensors, flow measurement systems or SCADA systems	Preparation = 6 hrs	Based on technical content, visual presentation, and explanation clarity
7	Case Study Analysis / Seminar	Case study on CPCB online effluent monitoring system, industrial CEMS, or smart river monitoring systems	Data collection/study = 5 hrs Report preparation = 5 hrs Total = 10 hrs	Based on technical depth, data interpretation, and practical relevance
