GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester-V

Course Title: Air Pollution and Control
(Course Code: 4351301)

Diploma programme in which this course is offered	Semester in which offered
Environmental Engineering	5th Semester

1.   RATIONALE

The air pollution levels in some of our cities have reached to such a level that it is causing health related problems and very poor visibility in winter months resulting in traffic accidents. It is therefore very important to monitor and control air pollution. The course will provide a detailed knowledge of air quality management with an emphasis on the sources of air pollution, including the effects on humankind, plants and animals. In depth awareness of central, state, and local regulatory requirements in respect of air pollution laws and regulations will be provided. Principles of air pollution prevention and control, equipment and technology used for the purpose will be dealt with description of control of specific gaseous emissions. This course is therefore a key course for environment engineers.

2.   COMPETENCY

The course content should be taught and with the aim to develop required skills in students so that they are able to acquire following competencies.

- **Measure different components of air pollution and suggest strategies to minimize them.**

3.   COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

a) Identify the sources, types, causes and effects of air pollution.
b) Calculate the stack height based on the meteorological components related to air pollution.
c) Select location and type of sampling.
d) Select appropriate air pollution control methods based on ambient conditions with consideration of air pollution control laws.
e) Explain control methods of specific gaseous emissions like SO2 & NO2

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA*	ESE	CA	ESE	
3	-	2	4	30	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-*Lecture;* **T** *– Tutorial/Teacher Guided Theory Practice;* **P** *- Practical;* **C** *– Credit,* **CA** *- Continuous Assessment;* **ESE** *- End Semester Examination.*

5.   SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the PrOs marked '*' are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Sampling and Analysis of PM10 in Ambient Air	I	04
2	Sampling and Analysis of PM2.5 in Ambient Air	I	04
3	Measurement of meteorological parameters (wind velocity, wind direction, humidity, temperature, solar insolation, rainfall) and drawing wind rose diagram.	II	04
4	Stack Emission Monitoring using Isokinetic Sampling	III	04
5	Indoor Air Quality Assessment using Multi Gas Monitor	III	02
6	Sampling and Analysis of PM10 & PM2.5 using Spectrometer	III	04
7	Laboratory scale study on few air pollution control devices.	IV	02
8	Sampling and Analysis of SO2 and NO2 in Ambient Air	V	04
			Total:28

Note

 i. More **Practical Exercises** *can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list**.**

ii. *The following are some* **sample** *'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed* **Practical Exercises** *of this course required which are embedded in the COs and ultimately the competency..*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
	For PrOs 1 to 7	
1	Identification of Glassware and Equipment to perform various test	10
2	Prepare experimental setup accurately	10
3	Observe and record readings accurately	40
4	Calculate results accurately	20
5	Interpret results and their conclusions	10
6	Submission for progressive assessment on time	10
7	Viva Voce	10
	Total	**100**

6.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	• **Analytical Balance** • **High volume air sampler** • **Filter media** • **UV Spectrophotometer** • **Flame photometer** • **Distillation Assembly** • **Chemical testing glasswares** • **Hot air oven**	1 to 14

7. AFFECTIVE DOMAIN OUTCOMES

The following *sample* Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.
   a) Work as a team member/ individual.
   b) Follow ethical practices.
   c) Follow safe practice on site and in laboratory.
   d) Practice of environmental friendly methods and processes.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:
   i.   'Valuing Level' in 1st year
   ii. 'Organization Level' in 2nd year.
   iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Air Pollutants**	1a. Describe the major atmospheric pollutants 1b. Describe different sources of atmospheric pollution. 1c. Interpret the effects of air pollution on humankind, plants and animal kingdoms.	1.1 Air pollution an Environmental problem. 1.2 Classification of air pollutants: Natural contaminants, Particulate, Gases and vapors, Primary and secondary air pollutants 1.3 Sources of Air pollution: Stationary sources, Mobile sources.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
	1d. Describe the effects of air pollution on society	1.4 Effects of air pollution on: human health, animals, plants, Properties, Society
Unit – II Meteorology	2a. Explain dispersion phenomenon of air pollutants covering diffusion, meteorological components, stability of atmosphere and corresponding plume shapes. 2b. Describe the process and instruments used for measuring of wind speed, direction and ambient temperature 2c. Explain the process of determining the stack height 2d. Describe the stability classes and their significance	2.1 Meteorological factors influencing air pollution: Dispersion, Temperature Lapse Rates and Stability. 2.2 Measurement of wind speed, direction and temperature 2.3 Effect of meteorological parameters on Plume behavior 2.4 Regalement chart for plume behaviour 2.5 Dispersion of air pollutants Determination of Stack height based on these parameters 2.6 Stability classes
Unit– III Air Pollution Sampling and Measurements	3a. Describe different method of sampling 3b. Select the sampling location 3c. Interpret characteristics of the sample measured. 3d. Describe the criteria of selection of sampling location	3.1 Sampling methods 3.2 Duration of Sampling 3.3 Ambient Sampling and its location: Collection of Gaseous Air Pollution, Collection of Particulate Matter 3.4 Stack Sampling and selection of sampling location
Unit– IV Air Pollution Control Methods and Equipment	4a. Explain principles of air pollution prevention and control measures with various control equipments at source. 4b. Discuss specific features and meaning of air pollution control laws, regulations at central, state and local bodies' level. 4c. Describe the selection criteria for collectors 4d. Describe the control of different types of gaseous emissions 4e. Describe the different	4.1 Types of collection methods. 4.2 Particulate Emissions Control Equipments: Gravity settling, cyclones, Fabric Filters, Electrostatic Precipitators, Wet Scrubbers 4.3 Selection of Collectors. Control of Gaseous Emissions: Absorption by Liquids, Adsorption by Solids 4.5 Air pollution control laws/acts at different central, state and local levels and by regulatory bodies. 4.6 Control of SO2: Chemistry of SO2, Lime and Limestone

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
	process for control of SO2 and NO2	Scrubbing, Wet lime scrubbing, Single Alkali scrubbing and Double Alkali scrubbing, Dry process 4.7 Control of NO2: Combustion control methods
Unit–V **Sector Wise Mitigation Measures to Control Air Pollution**	Identify mitigation methods for various sectors like Urbanisation, Transportation, Industrialisation, Power generation, Agricultural activities	5.1 Mitigation measures for Urbanisation like City Planning, Clean technology interventions in rural areas like clean fuel, solar lighting, paved roads, ban on refuse burning etc. 5.2 Mitigation measures for Transportation like travel demand management, avoid-shift-improve approach, use of public transportation, encourage non-motorized transport, fuel quality and vehicle emission norms etc. 5.3 Mitigation measures for Industrialisation like vigilance and enforcement etc. 5.4 Mitigation measures for Power generation like Improved power supply, monitoring of control equipments etc. 5.5 Mitigation measures for Agricultural activities like power generation from crop residue

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Air Pollutants	08	04	06	02	12
II	Meteorology	08	04	06	02	12
III	Air Pollution Sampling and Measurements	10	06	06	04	16
IV	Air Pollution Control Methods and Equipment	12	08	10	02	20
V	Sector Wise Mitigation Measures to Control Air Pollution	04	04	04	02	10
Total		**42**	28	**32**	**14**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10.   SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a)   Preparation of chart of various methods to analyze different forms of Nitrogen
b)   Preparation of chart of various methods to analyze Fluoride
c)   Study and List the effects of Nitrogen and Phosphorus in water and waste water
d)   Undertake micro-project.
e)   Give seminar on any relevant topic.

11.   SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a)   Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
b)   Guide student(s) in undertaking micro-projects.
c)   *'L' in section No. 4* means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d)   About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
e)   With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
f)   Guide students on how to address issues on environment and sustainability

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be **individually** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed Six.**

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make a report after gathering information about the values of ambient air pollution in your town or city and compare them with that of other cities

b) Prepare chart for: Different types of Plume behaviour.

c) Prepare working model for air control equipment

d) Study and prepare report on effect of lockdown on Air Quality in various countries.

e) Study and prepare report on National Clean Air program and identify its limitations

f) Prepare a list of significant steps taken by the government to curb air pollution

g) Study and prepare report on strategies to overcome challenges in NCAP

h) Study and enlist various National policies and programs proposed by government to tackle air pollution

i) Enlist major international treaties formed to tackle air pollution

j) Study and prepare report on role of air pollution in environmental issues like ozone depletion, global warming, climate change, acid rain

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Air Pollution and Control	Rao, M.N and Rao, H.N.	McGraw Hill Education; 1st edition (1 July 2017); ISBN-13 : 978-0074518717
2	Air Pollution and Control	K.V.S.G. Muralikrishna	USP,2017, ISBN-13 : 978-9383828593
3	Air Pollution: Its Origin and Control	Wark and Warner	Pearson; 3rd edition (15 January 1998), ISBN-13 : 978-0673994165
4	Textbook of Air Pollution And its Control	S.C. Bhatia	Atlantic (1 December 2021), ISBN-13 : 978-8126908257
5	Handbook of Air Pollution Analysis	Roy M. Harrison	Springer, ISBN-13 : 978-9401083119
6	IS:5182 , Methods for measurements of air pollution(Part-I,II,IV,V,X)	BIS	BIS, May 1999

14.   SOFTWARE/LEARNING WEBSITES

a) www.gpcb.gov.in

b) https://cpcb.nic.in/about-namp/www.neeri.res.in

c) www.Nptel.ac.in

d) https://www.indiacode.nic.in/

15.   PO-COMPETENCY-CO MAPPING

Semester II	Environmental Chemistry-II (Course Code:4341305)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1 Environmental planning & deisgn	PSO 2 Environmental Impact Assessment	PSO 3 (If needed)
Competency	i. Measure different components of air pollution and suggest strategies to minimize them.									
Course Outcomes a) Identify the sources, types, causes and effects of air pollution.	3	3	-	-	3	-	2	3	3	-
b) Calculate the stack height based on the meteorological components related to air pollution.	3	3	3	-	3	-	2	3	3	-
c) Select location and type of sampling.	3	3	3	2	3	-	2	3	3	-
d) Select appropriate air pollution control methods based on ambient conditions with consideration of air pollution control laws.	3	3	3	-	3	-	2	3	3	-
e) Explain control methods of specific gaseous emissions like SO2 & NO2	3	3	3	-	3	-	2	3	3	-

Legend: '**3**' for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16.   COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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