B. Sc. in Civil Engineering
7th semester

Date: 06 October, 2023
Time: 10:30 am – 12:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Mid Term Examination
Course Number: CEE 4735
Course Title: Environmental Pollution and Its Control

Winter Semester : 2022 - 2023
Full Marks: 75
Time : 1.5 Hours

There are 03 (three) questions. Answer all questions. Programmable calculators are not allowed. Do not write on this questions paper. The symbols have their usual meaning. Assume reasonable data if needed.

		Marks	CO	PO
1.	As the Nasir Glass industry grapples with its environmental impact, it's committed to change. Their mission is to establish a new production unit's stack that reduces O_3, PM, CO, and SO_2 emissions. In industry, designing an effective stack is essential, harmonizing technology and processes.			
(a)	What is the difference between lapse rate and adiabatic lapse rate? Classify the atmospheric stability.	(04)	CO1	PO1
(b)	Identify the possibilities to predict what will happen to gases emitted from the stack by comparing the ambient lapse rate to the adiabatic lapse rate.	(06)	CO1	PO1
(c)	According to the pollutant concentration given on the following table what AQI and air quality description should be reported for the air pollution on the days given? Write comments based on your results.	(15)	CO2	PO2

Pollutant	05 October, 2023	06 October, 2023
O_3 (ppm) 8 hour	0.0798	0.0954
PM_{10} (µg/m³)	250.43	260.89
CO (ppm)	10	16
SO_2 (ppm)	0.2222	0.2281

*Refer to Table 1 for additional data.

2. Gazipur's Air Quality Index (AQI) on October 4, 2023 was 124, attributing the pollution primarily to particulate matter. In response, the city corporation (GCC) is taking a proactive step by considering the invitation of EPA researchers to conduct air quality modeling, highlighting their commitment to addressing environmental concerns and suggesting some control strategies.

(b) Which factors should be considered in air quality modeling? **(04)** CO1 PO

(c) Discuss the particle deposition mechanism. **(06)** CO1 PO1

(c) In pursuit of environmental sustainability, the GCC adopts a cost-effective move by introducing a settling chamber system to mitigate pollutants. Their approach involves the simultaneous operation of two identical chambers, jointly handling a total flue gas flow rate of 65,000 m^3/h. Importantly, there is strict isolation between these chambers both horizontally and vertically, ensuring no gas mixing. This design is expected to yield an overall particulate collection efficiency of 85% **(09)** CO3 PO2

    i. Analyse the overall performance of particulate collection efficiency if the flue gas is unintentionally distributed unevenly such that one chamber gets 70% of the gas flow and the other receives the rest.

    ii. What should be the flue gas flow rate for 100% collection efficiency?

(d) A cyclone separator was chosen as an alternative having an inlet width of 15 cm and the shortest length of 25 cm with diameter of 0.50 m. The device operates at five effective turns. The gas temperature is 345K and inlet velocity is 20m/s. Also, the average particle size is 10μm with particle density 1.2 g/cm3. The viscosity of air at 345K is 0.0745 kg/m-h. **(06)** CO4 PO3

    i. Design the Determine the cut diameter.

    ii. Is this a high efficiency cyclone?

3. Runner Group is on a mission to introduce new hybrid motor vehicles in Bangladesh, acknowledging the Department of Environment's concerns regarding vehicles as a significant source of air pollution. In addition, as a control strategy they are investing in a cyclone separator plant to further contribute to environmental improvement. The designer's vision involves implementing a cyclone chamber with a barrel diameter of 1.5 meters, catering to a volumetric flow rate of 0.58 m^3/s. In this setup, the air's viscosity is 2.07×10^{-5} kg/ms, while the particles, which need to be separated in the system, have a density of 1602 kg/m3. Furthermore, the air density within this system was measured at 1.22 kg/m3.

(a) Write down the steps in developing a control strategy. **(05)** CO1 PO1

(b) Describe the effect of air-fuel ratio on carbon monoxide, nitrogen oxides, and hydrocarbons emissions based on power, and fuel economy. **(05)** CO1 PO1

(c) Design the cyclone separator for separating 40 μm particulate matter from polluted air. **(06)** CO4 PO3

(d) Analyse the change of collection efficiency of this cyclone separator with the change in particle diameters shown in Table 2. **(09)** CO3 PO2

Table 1: Breakpoint table for PSI Calculation

O[1] (ppm) 8-hour	O₃ (ppm) 1-hour	PM₁₀ (µg/m3)	PM₂.₅ (µg/m3)	CO (ppm)	SO₂ (ppm)	NO₂ (ppm)	PSI	
0.000 - 0.069	-	0.0 - 154	0.0 - 4.4	0.000 - 0.034			0 - 50	Good
0.070 - 0.084	-	55 - 154	15.5 - 65.4	4.5 - 9.4	0.035 - 0.144		51 - 100	Moderate
0.085 - 0.104	0.125 - 0.164	155 - 254	65.5 - 150.4	9.5 - 12.4	0.145 - 0.224	[2]	101 - 150	Unhealthy for Sensitive Groups
0.105 - 0.124	0.165 - 0.204	255 - 354	150.5 - 250.4	12.5 - 15.4	0.225 - 0.304	[2]	151 - 200	Unhealthy
0.125 - 0.374 (0.155 - 0.404)[note]	0.205 - 0.404	355 - 424	150.5 - 250.4	15.5 - 30.4	0.305 - 0.604	0.65 - 1.24	201 - 300	Very unhealthy
[2]	0.405 - 0.504	425 - 504	250.5 - 350.4	30.5 - 40.4	0.605 - 0.804	1.25 - 1.64	301 - 400	
[2]	0.505 - 0.604	505 - 604	350.5 - 500.4	40.5 - 50.4	0.805 - 1.004	1.65 - 2.04	401 - 500	Hazardous

[1] Areas are required to report the PSI based on 8-hour ozone values. However, these are areas where a PSI based on 1-hour ozone values would be more protective. In these cases for both the 8-hour and the 1-hour ozone values may be calculated and the maximum PSI reported.
[2] NO₂ has no short-term NAAQS and can generate a PSI only where a PSI value of 200.
[3] 8-hour O₃ values do not define higher PSI values (> 301). PSI values of 301 or higher are calculated with 1-hour O₃ concentrations.
[note] The numbers in parentheses are associated 1-hour values to be used in this overlapping category only.

Table 2: Particle Size Range, µm

0 – 2
2 – 4
4 – 6
6 – 10
10 – 18
18 – 30
30 – 50
50 – 100