Ref No: EX/PG/CE/T/127E/2017

# Master of Civil Engineering 1st Year 2nd Semester Examination 2017

## Air Pollution and Control

Time: Three Hours | Full Marks: 100

(**60 marks for Part 1** & 40 marks for Part 2)

**Part 1**

Answer **Question No. 1** and any **Two** from the rest.

Answers should be brief. Any relevant data may be assumed, if needed. Turner's $\sigma_y$ and $\sigma_z$ and Pasquill's stability chart may be allowed. Please answer **Question No. 1** in first few pages of your answer script.

1. a) Why is Gaussian Air Pollution Model (GAPM) essential in environmental impact assessment study?

   b) What type of model is GAPM?

   c) What is the significance of 'flat terrain' assumption?

   d) Name four meteorological input parameters for GAPM.

   e) Differentiate time-averaged plume boundary and instantaneous plume boundary.

   f) Name the four factors which are multiplied to get the final expression of GAPM.

   g) Describe the significance of the point (0, 0,-H), in development of general expression of GAPM.

   h) Describe the role of a windrose to decide about the downwind and crosswind direction of GAPM.

   i) Describe 'night' with respect to Pas00quill stability class table.

   j) Draw a sketch to show the effect of two vertical constrains on plume dispersion. 2x10=**20**

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2. a) The general Gaussian expression is as follows:

$$C_{(x,y,z;H)} = Q/(2\pi\,\sigma_y\,\sigma_z U)\,[\text{Exp}\,\{-y^2/2\,\sigma_y^2\}]\,[\text{Exp}\,\{-(H-Z)^2/2\,\sigma_z^2\} + \text{Exp}\,\{-(H+Z)^2/2\,\sigma_z^2\}]$$

The notations have their usual meanings. Now find expressions for following modifications (steps should be shown in details): (i) receptor at ground level (GL) & $x<x_g$ (ii) source is at GL & $x> x_g$ (iii) source and receptor are at GL & $x> x_g$

b) Define plume. Hence, develop *the relation between $\sigma_z$ and H at $x_g$* . How stability class may affect calculation of $x_g$ and show that with a mathematical example.

c) A stack with effective height 60m, emitting at the rate of 30 g/s. Winds are estimated at 4 m/s at the stack height, the solar insolation is slight, and there is an inversion at 130 m. Estimate the ground-lev concentration at the point where reflections begin to occur from the inversion and at a point twice t distance downwind. How to calculate concentrations between these two points? What may be prob the type of inversion? What may be the probable plume pattern? 5+8+7=2

3. a) Write the relevant assumptions related with GAPM for the following cases

(a) mechanical turbulence (b) wind shear (c) type of emission (d) change of mass of pollutant (e) concentration distributions

b) At a point directly downwind from a ground-level source, the 15 min concentration is $3.4\times 10^{-3}$ g/m$^3$ What would be the 2 hour concentration at this point? The 'p' value may be taken as 0.2.

c) Find the ratio of *concentrations at GL* to the *concentration at the effective stack height level* for $x_{max}$ (the downwind distance of $C_{max}$). 10+4+6=

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### Part 1

me: Three Hours

Full Marks: 100

a) To predict downwind ground level $SO_2$ concentration from a coal fired thermal power plant in a overcast condition, following database is collected:

Source characteristics: (i) physical stack height = 100m, (ii) internal radius 5 m (iii) exit speed = 20m/s (iv) exit temperature = 80°C (v) rate of coal burn = 3000 t/day (vi) S content of coal = 1.4 percent

Meteorological condition: (i) wind speed at anemometer height = 8m/s (ii) ambient temp - 10°C

Receptor location = 6 km downwind on flat terrain

Calculate the said concentration. Briggs' model may be used to calculate plume rise.

b) Write the co-ordinates of following points in Gaussian Co-ordinate system:

(i) any point on plume centerline (ii) the virtual source

(iii) at the stack tip (iv) any point on ground level center line

c) Write the name of following criteria pollutants:

(i) coloured gaseous criteria pollutant (ii) secondary gaseous criteria pollutant

(iii) dissociable criteria pollutant absorbing UV ray and (iv) most abundant criteria pollutant

d) How is wind direction reported?

e) Correlate the product of $\sigma_x$ & $\sigma_y$ with maximum ground level concentration.

f) Why is $\sigma_y$ missing in the expression of line source model? 9+2+2+2+3+2=**20**

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**Part 1**

Time: Three Hours Full Marks:

***Some of the following equations may be required*** (notations have their usual meanings):

1) $\Delta h = 2.6\,(F/uS)^{1/3}$

2) $F = gr^2 v_s (1 - T_a/T_s)$

3) $S = (g/T_a)(\Delta T_a/\Delta z + 0.01°C/m$

4) $\Delta h = [1.6F^{1/3}(x_f)^{2/3}]/u$

5) $x_f = 120\,F^{0.4}$, if $F \geq 55\ m^4/s^3$

6) $x_f = 50\,(F)^{5/8}$ if $F \leq 55\ m^4$

7) $C = Q / [(2\pi)^{1/2}\, u\, \sigma_y L]$

8) $\Delta h = [\, v_s d/u\,][1.5 + 2.68 \times 10^{-3} p\,(1 - T_a/T_s) d]$

9) $C_{(x,y,0:H)} = [\, 2q/(2\pi)^{1/2}\, \sigma_z u \sin\theta][\, \exp(-H^2/2\,\sigma_z^2)]$

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M.E. CIVIL ENGINEERING 1st YEAR 2nd SEMESTER EXAMINATION, 2017

SUBJECT: Air Pollution and Control

Time: Three hours

Full Marks 100
(40 marks for part II)

Use a separate Answer-Script for each part

**Part-II**

Question no. **1** is compulsory
Answer any **two** from the rest
*(Assume any data, if required, reasonably)*
(Lapple's Efficiency Curve may be used)

1.

a) Mention at least five action plans in brief to minimize the air pollution of Kolkata. 3

b) Mention the name of the methods for measuring ambient $SO_2$ and $NO_2$ concentration. 2

c) Why $PM_{10}$ and $PM_{2.5}$ are considered as criteria pollutants for NAAQS (2009) without considering total SPM? What is your opinion regarding inclusion of $PM_1$ in future NAAQS of India? 4

d) Explain the significance of isokinetic sampling for SPM and $SO_2$ monitoring. 3

e) Describe one post-combustion non-regenerable wet system of flue gas desulfurisation. 4

f) Why generation of 'fuel NOx'is easier than 'thermal NOx'in furnace? Describe one regenerable, post generation,simultaneous $SO_2$ and NOx control strategy. 5

g) Mention one catalytic conversion process of CO to $CO_2$ at ambient temperature. 3

2. An air stream with a flow rate of $6m^3/s$ is passed through a cyclone of standard properties. The diameter of the cyclone is 2 m. and the viscosity of air is $2.1\times10^{-5}$ kg/m.s. Determine the amount of removal/$m^3$ of flue gas, for particles with a density of 1.6 g/$cm^3$ and diameter of 5μm and10μm (30:70 w/w) when theirtotal concentration is 300 μg/$m^3$ of flue gas. 8

3. Design a parallel plate single-stage electrostatic precipitator (ESP) from the following data:

Required efficiency = 99.5%; Gas flow rate = 150000 $m^3$/hr

Particle drift velocity = 0.16 m/s; Collectrode spacing = 0.25 m $^c/_c$

Depth of collectrode = 3.5m; Height of collectrode = 8m; Gas flow velocity = 1.8 m/s

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4.

A Baghouse filter is used to treat 50 $m^3$/s of an emission with a particulate concentration of 0.03 kg/$m^3$. It is known that $k_o$ and $k_d$ (with usual notations) are 50000 N.s/$m^3$ and 50000 $s^{-1}$ respectively. The maximum allowable pressure drop is 4000 N/$m^2$ and the filter must operate for 8 hrs. between cleanings. If there is no restriction on filtering velocity, determine the number of bags used in the baghouse when the size of each bag is 0.3m in diameter and 6 m long.

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