CVL728: ENVIRONMENTAL QUALITY MODELLING

Major Exam

Time: 2 Hrs. **Marks: 40**

Date: 09.05.2016

NOTE: *Precise answers of the questions are expected. Provide neat sketches/figures wherever required.*

Q1. Answer the following

(a) The mass of the control volume can change with time (True /False) [1]

(b) Control volume is defined based on Eulerian approach (True/False) [1]

(c) Turbulent steady flows cannot be represented by the time average velocity (True/False) [1]

(d) If the density of lower layer of fluid is greater than density of upper layer of fluid, it would lead to _____ (enhance/reduce) turbulence. [1]

(e) When turbulence in ABL is maintained by buoyant forces, the ABL is in _____ (convective/isothermal) condition. [1]

(f) Diffusivity is a property of fluid (True/False) [1]

(g) Define Eddy diffusivity. [1]

(h) Write equations for following: [1.5+1.5]

1. Acceleration of fluid particle in a velocity field. Identify the *convective* and *local* accelerations in the same.
2. Motion for a turbulent real fluid flow.

Q2. Briefly and precisely answer the following:

(a) Define Entropy. Write the expressions for first law of thermodynamics and second law of thermodynamics following CV approach [3]

(b) Differentiate between [2+2]

1. Molecular Diffusion and Turbulent Diffusion
2. Turbulent flow and Laminar flow

(c) Explain the characteristics of Turbulent flows. [2]

Q3. Answer the following

(a) What are Reynolds and Richardson numbers? Write their expressions, explaining the terms. [2+2]

(b) A sheet of BCC Fe 1.0 mm thick is exposed to a carburizing gas on one side and a decarburizing gas on the other at 725°C. After reaching steady state, the Fe membrane is quenched to room temperature, and the concentrations at each side of the membrane are 0.270 kg/m^3 and 1.688 kg/m^3. Calculate the diffusion coefficient if the diffusion flux is 1.4×10^{-5} g/m^{2}sec. [4]

(c) Sketch a neat diagram showing forces/stresses acting in x-direction on all faces of fluid particle of mass dm. Using Taylor series, write the stress equations. [5]

Q4. Three reactors having variable depths and surface areas are connected in series. At the outlet of the third reactor, half of the inlet flow is recirculated into the first reactor. It has been observed that the pollutant has been degrading at a rate of 0.2/year in the reactor 2 only. If inlet flow is 2×10^6 m^3/year,

(i) Write down the mass balance equations for all the reactors

(ii) Calculate the concentration in each of the reactor.

Assumptions

a. The inlet concentration of the pollutant is zero.

b. No Pollutant settling takes place [8]

	Reactor 1	Reactor 2	Reactor 3
Volume (m^3)	2×10^6	4×10^6	3×10^6
Loading (kg/day)	3	4	2