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University of Petroleum & Energy Studies, Dehradun

Examination	**: End Semester Examination Dec 2017**
Program Name	**: M. Tech (PLE)**
Semester	**: I**
Subject Name	**: Transport Phenomena**
Duration	**: 3 hrs.**
Subject Code	**: MREG 711**
Max. Marks	**: 100**
Pages	**: 2**

Instructions:

1. **Put your Roll No. immediately on the question paper, and accompanying charts. Do not put any other comments on the question paper.**
2. **Answer all parts of a question at one place only. Mark question number and part number clearly in the left margin. Assume necessary data, and justify your assumptions.**

Section A: 10x6 = 60 Marks: Answer All

Q1. Explain difference between Newtonian and non-Newtonian fluids by showing a graph of τ versus Gamma Dot. Explain why some fluids show shear thinning while others are shear thickening. How can we classify Bingham plastics. What is the effect of non-Newtonian behavior on the velocity profile of flow of liquid through pipe? Explain clearly with help of equations and diagram. **[10 marks]**

Q2. What was Reynolds Experiment which described clearly the idea of turbulence. Explain how instantaneous velocity leads to turbulence. Define eddy viscosity and eddy diffusivity and write the full Reynolds Tensor. For water with free stream velocity of 1.5 m/s, find the location of onset of turbulent for flow over flat plate. Solve the problem in MKS units and assume appropriate data. **[10 marks]**

Q3. Why are the non-Newtonian fluids called polymeric liquids? The kinetic theories for polymers can be divided roughly into two classes: *network theories* and *single-molecule theories*. Explain the difference between them by underlining the physics behind them, and drawing neatly labeled diagrams. **[10 marks]**

Q4. Explain the concept of partial derivate and material derivative. Write also the equation of motion and equation of continuity and explain each term. **[10 marks]**

Q5. For the steady, fully developed, laminar flow in a circular tube of radius *R* we know that the velocity distribution and the average velocity are given by

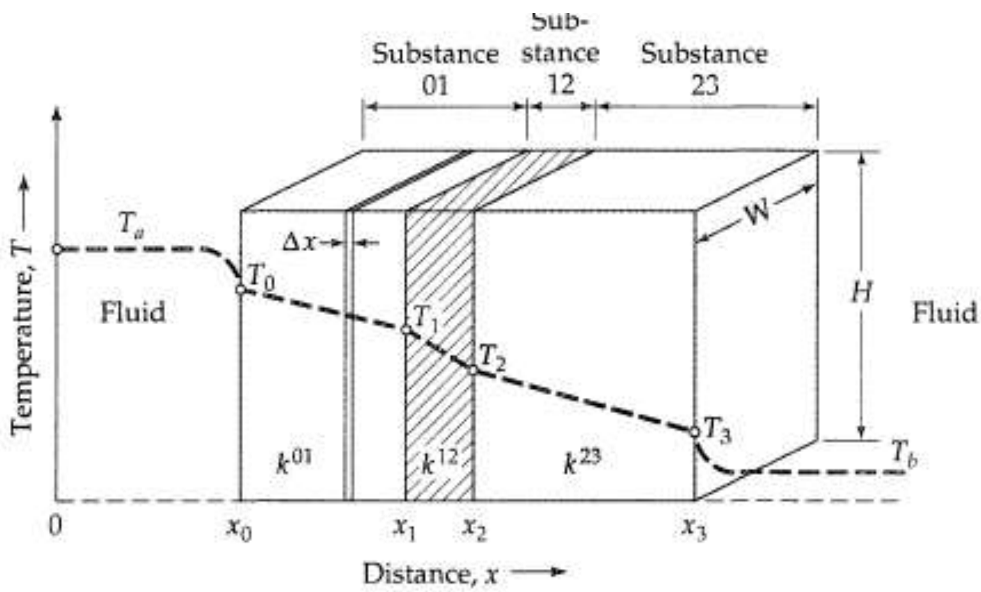
$$\frac{v_z}{v_{z,\max}} = 1 - \left(\frac{r}{R}\right)^2 \quad \text{and} \quad \frac{\langle v_z \rangle}{v_{z,\max}} = \frac{1}{2} \qquad (\mathrm{Re} < 2100)$$

In case of turbulent flow, the velocity distribution is given by power law, as per following equation:

$$\frac{\bar{v}_z}{v_{z,\max}} \approx \left(1 - \frac{r}{R}\right)^{1/7} \quad \text{and} \quad \frac{\langle \bar{v}_z \rangle}{v_{z,\max}} \approx \frac{4}{5} \qquad (10^4 < \mathrm{Re} < 10^5)$$

For a pipe of ID of 6 inch, with $\langle v_z \rangle = 2$ m/s, plot $v_z(r)$ for laminar flow as a function of radius from r = -R to r = R on the graph sheet. Presuming that $v_{z,\,max,\,laminar} = v_{z,\,max,\,turbulent}$, plot the $v_z(r)$ for turbulent flow on the same graph. **[10 marks]**

Q6. Three materials of different substance are in contact with each other. They are in turn in contact with fluids at T_a and T_b. Write the shell energy balance and derive an expression for the heat flux in terms of T_a, T_b, and conductivity. **[10 marks]**



Section B: 20x2 = 40 Marks [Two Questions, Answer ALL]

Q7. A. Explain the usual ranges of diffusivities of solids, liquids, and gases. Also elaborate on the pressure and temperature dependence of diffusivity for gases. **[10 marks]**

B. Diffusivity of a component in a mixture of components can be calculated using the Wilke's relation given below. Calculate the diffusivity of CO_2 [1], O_2 [2], and N_2 [3] in a gas mixture having the composition CO_2 = 28.5 %, O_2 = 15%, N_2 = 56.5%, The mixture is at 273 K and at 1 atm. pressure. The binary diffusivities at 273 K are given as $D_{12}P = 1.874$ m^{2}Pa/sec, $D_{13}P = 1.945$ m^{2}Pa/sec, and $D_{23}P = 1.834$ m^{2}Pa/sec. **[10 marks]**

$$D_{1-mixture} = \frac{1}{\dfrac{y_2'}{D_{1-2}} + \dfrac{y_3'}{D_{1-3}} + \ldots\ldots\ldots + \dfrac{y_n'}{D_{1-n}}}$$

Q8. The transport equation for binary system can be given as following: $N_A = -C D_{AB} \dfrac{d y_A}{d Z} + y_A N$

a. Prove that $D_{AB} = D_{BA}$ for binary system. **[5 marks]**
b. Derive the equation for Molar Flux of A, N_A, and concentration profile of A, i.e., $C_A(z)$, for Equi-Molar Counter Diffusion (EMCD) of A and B. Draw the $C_A(z)$ as a function of z. **[10 marks]**
c. How will the equations change for diffusion of A through stagnant B? **[5 marks]**