(3 hour) Max Marks: 80

NB:

1. Question No. 1 is compulsory
2. From the remaining five questions answer any three.
3. All parts of a question and subquestion should be attempted in one place.
4. Figures to the right indicate full marks

1. a. Describe the analogies between momentum, heat and mass transfer [5]
   b. Explain the shear stress versus shear strain curve for Newtonian and non-Newtonian fluid. [5]
   c. Explain the temperature dependency of thermal conductivity of liquid and gas. [5]
   d. Differentiate between molar flux J_A and N_A. [5]

2. a. Derive equation of continuity. [12]
   b. The space between two parallel plates is 0.5 cm. It is filled with oil of viscosity $\mu = 0.4\times10^{-2}$ Pa.s. at 303 K. The lower plate is pulled at a relative velocity of 0.366 m/sec greater than the top plate. Calculate the shear stress and shear rate. [8]

3. a. Derive the velocity profile for flow through a circular tube and find the average velocity and maximum velocity for flow through a circular tube [14]

   b. A small capillary tube with an inside diameter of 2.2×10^{-3} m and length of 0.317 m is being continuously used to measure the flow rate of liquid having density of 990 kg/m^3 and $\mu=1.13\times10^{-3}$Pa.sec. The velocity of liquid is 0.275m/sec. Calculate pressure drop in the tube. [6]

4. a. Show that the temperature rise is a parabolic function of the distance r from the wire axis for heat conduction with an electrical heat source. [12]

   b. A furnace wall is exposed to hot gases at 1100K. The wall consists of 0.12m of fire brick and 0.25 m of common brick. Heat transfer coefficients on the hot side are 3000 W/m^{2}K and 22 W/m^{2}K on the outside. Ambient air is at 300K. What is the heat transfer rate per square meter of wall? k=0.138W/mK for both brick. [8]

5. a. Write the dimensionless numbers correlating mass transport, heat transport and momentum transport processes. [8]

   b. In a O_2 –N_2 gas mixture at 1 atm and 25°C, the concentration of O_2 at two planes, 2 mm apart, are 10 and 20 % (v/v) respectively. Calculate the flux of diffusion of O_2 for the case where

   i. N_2 is non-diffusing.

   ii. There is equimolar counter diffusion of gases. Data: $D_{O2-N2} = 1.86 \times 10^{-5}$ m^2/sec at 0°C and $D_{O2-N2} = 2.064 \times 10^{-5}$ m^2/sec at 25°C [12]

6. Write short notes on **any four**: [20]

   a. Role of Peclet no. in mass transfer and heat transfer processes

   b. Hagen-Poiseuille equation.

   c. Diffusion of gas A through non diffusing gas B

   d. Non-Newtonian fluids

   e. Commonly used boundary conditions in laminar flow momentum transport problems.
