B. Tech-3rd(MME)

Transport Phenomena

Full Marks : 50

Time : $2\frac{1}{2}$ hours

Answer **all** questions

The figures in the right-hand margin indicate marks

Symbols carry usual meaning

Any supplementary materials to be provided

1. Answer *all* questions : 2×5

(*a*) An oil with density 0.9 gm/cm^3 and viscosity 0.016 poise is flowing through a 20 cm diameter pipe. The maximum shear stress at the pipe wall is 2.5 N/m^2. Determine maximum velocity ?

(*b*) Which of the following statements are true for the above equation ?

$$\frac{\partial^2 T}{\partial x^2} = (1/\alpha)\frac{\partial T}{\partial t}$$

(*i*) One dimensional heat flow

(*ii*) No heat generation

(*iii*) Steady state

(*iv*) Unsteady state

(*c*) In Heisler chart, the slope of the graph represents which of the following dimensionless quantity ?

(*i*) Fourier Number

(*ii*) Biots Number

(*iii*) $(\text{Nusselt Number})^{-1}$

(*iv*) $(\text{Biots Number})^{-1}$

(*d*) Which of the following is/are dimensionless ?

(*i*) $\frac{d.V.\rho}{\nu}$

(*ii*) $\frac{\mu.C}{k}$

(*iii*) $\frac{h.L}{k}$

(*iv*) $\frac{\nu.L}{k}$

(*e*) In an experiment, cylindrical samples of diameter 5 cm and length 10cm are used. The two thermocouples in each sample are placed 3 cm apart. After initial transients, the electric heater is observed to draw 0.4 A at 110 V and both differential thermometers read a temperature difference of 15°C. Determine the thermal conductivity of the sample.

2. (*a*) Prove that the rate of discharge (Q) in pipe flow depends on the equation :

$$Q = \frac{\pi.\Delta P.d^4}{128.\pi.L}$$

Where ΔP is pressure difference over a distance L,
Q is rate of discharge and d is diameter of pipe. 8

Or

(*b*) A horizontal venturimeter with inlet and throat diameters 30 cm and 15 cm respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet and the throat is 20 cm of mercury.
(*i*) Determine the volume flow rate, and
(*ii*) Determine the mass flow rate.
Take $C_d = 0.98$. 8

3. (*a*) At low velocities (laminar flow), the volume flow Q through a small-bore tube is a function only of the tube radius R, the fluid viscosity μ, and the pressure drop per unit tube length dp/dx. Using the Buckingham Pi Theorem, find an appropriate dimensionless relationship. 8

Or

(*b*) A storage tank consists of a cylindrical section that has a length and inner diameter of L = 2m and Di = 1m, respectively, and two hemispherical end sections. the tank is constructed from 20-mm-thick glass (Pyrex) and is exposed to ambient air for which the temperature is 300 K and the convection coefficient is 10 W/m^2K. The tank is used to store heated oil, which maintains the inner surface at a temperature of 400 K. Determine the electrical power the must be supplied to

a heater submerged in the oil if the prescribed conditions are to be maintained. Radiation effects may be neglected and the Pyrex may be assumed to have a thermal conductivity of 1.4 W/m. K. 8

4. (*a*) A steel ball having specific heat 0.46 kJ/kg.C, k = 35 W/m.C and diameter 5 cm and initially at 450° C is suddenly placed in a controlled environment in which temp is maintained at 100°C. The convective heat transfer coefficient is 10 W/m^2.C. Calculate the time required for the ball to attain a temperature of 150°C. (Take density of steel as 7.8 kg/m^3). 8

Or

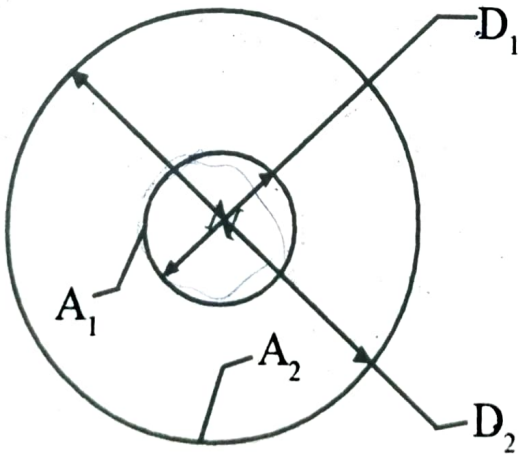
(*b*) Air at 20°C is flowing along a heated plate at 134°C with a velocity of 3m/s. The plate is 2m long. Heat transferred

from first 40 cm from the leading edge is 1.45 kW. Determine the Prandtl number. Properties of air at 77°C : $\rho = 0.998$ kg/m^3; $\nu = 20.76 \times 10^{-6}$ m^2/s; $C_p = 1.009$kJ/kg.K ; $K = 0.03$ W/mK.

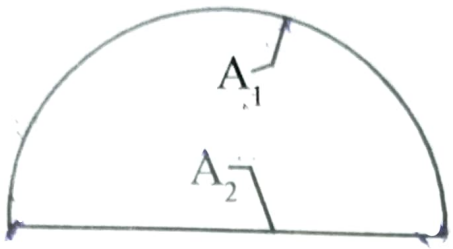
Use the following correlation :

$$N_{ux} = 0.332\ Re^{0.5}\ Pr^{0.33}.$$ 8

5. (*a*) Determine F_{12} and F_{21} for the following configurations using the reciprocity theorem and other basic shape factor relations. 4



(*b*) Determine the F_{22} for the configuration (Surface 2 is a cylinder of diameter D and length L (= 2D) ? 4



Or

A circular ice rink 25 m in diameter is enclosed by a hemispherical dome 35 m in diameter. If the ice and dome surface may be approximated as blackbodies and are at 0 and 15°C, respectively, what is the net rate of radiative transfer from the dome to the rink ? 8

6. (*a*) What id Fick's first law and second law of diffusion ? 8