CBCS Scheme

USN | | | | | | | | | | 15AE53

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. *Answer any FIVE full questions, choosing one full question from each module.*
2. *Use of heat transfer and data handbook is permitted.*

Module-1

1 a. Explain Fourier's law of conduction. **(06 Marks)**
b. Explain types of mass transfer with examples. **(06 Marks)**
c. Briefly explain Fick's law of diffusion. **(04 Marks)**

OR

2 a. Explain Newton's law of cooling and derive the governing equation for convective heat transfer. **(06 Marks)**
b. Briefly explain Stefan Boltzmann law. **(04 Marks)**
c. Explain combined heat transfer mechanism. **(06 Marks)**

Module-2

3 a. One end of a long rod is inserted into furnace, while the other end projects into ambient air. Under steady state, the temperature of the rod is measured at two points, 75 mm apart and found to be 125°C and 88.5°C, while the ambient temperature is 20°C. If the rod is 25 mm in diameter and h is 23.36 W/m^2K, determine the thermal conductivity of the rod material. **(06 Marks)**
b. Derive the three dimensional general heat conduction equation in Cartesian coordinates. **(04 Marks)**
c. Derive an expression for instantaneous heat transfer and total heat transfer using lumped heat analysis for unsteady state heat transfer to a body from the surroundings. **(06 Marks)**

OR

4 a. Derive an expression for temperature distribution and heat flow through a fin of uniform cross section with the end insulated. **(06 Marks)**
b. A rod (K = 200 W/m.K), 5 mm in diameter and 5 cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 25°C with convection heat transfer coefficient of 100 W/m^2K. Assuming other end is insulated, determine:
i) The temperature of rod at 20 mm distance from the end at 100°C
ii) Heat dissipation rate from the surface of the rod
iii) Effectiveness. **(06 Marks)**
c. Derive the three dimensional general heat conduction equation in cylindrical coordinates. **(04 Marks)**

Module-3

5 a. Obtain an empirical expression in terms of dimensionless numbers for heat transfer coefficient in the case of forced convection heat transfer. **(08 Marks)**
b. Dry air at atmospheric pressure and 20°C is flowing with a velocity of 3 m/s along the length of a long flat plate, 0.3 m wide, maintained at 100°C. Calculate the following quantities at x = 0.3 m.
i) Boundary layer thickness
ii) Average friction coefficient
iii) Thickness of thermal boundary layer
iv) Rate of heat transfer from the plate between x = 0 and x = x by convection. **(08 Marks)**

OR

6 a. Explain the following:
   i) Velocity boundary layer
   ii) Thermal boundary layer (06 Marks)

b. Explain the significance of following:
   i) Grashoff Number
   ii) Nusselt number
   iii) Prandtl number (06 Marks)

c. A horizontal plate 1m × 0.8m is kept in a water tank with the water surface at 60°C providing heat to warm stagnant water at 20°C. Determine the value of convection heat transfer coefficient. (04 Marks)

Module-4

7 a. With assumptions, derive an expression for LMTD for a parallel flow heat exchanger. (08 Marks)

b. What is fouling factor in heat exchanger and what is the effect of it on heat exchanger? (02 Marks)

c. An oil cooler consists of straight tube of 2 cm outer diameter and 1.5 cm inner diameter, enclosed within a pipe and concentric with it. The external pipe is well insulated. The oil flows through the tube at 0.05 kg/s (C_p = 2 kJ/kg.K) and cooling fluid flows in the annulus in the opposite direction at the rate of 0.1 kg/s (C_p = 4.2 kJ/kg.K). The oil enters the cooler at 180°C and leaves at 80°C, while cooling liquid enter the cooler at 30°C. Calculate the length of the pipe required if heat transfer coefficient from oil to the surface is 1720 W/m^2K and from metal surface to coolant is 3450 W/m^2K. Neglect the resistance of the tube wall. (06 Marks)

OR

8 a. Explain : i) Stefan Boltzman law, ii) Black body. (04 Marks)

b. Obtain an expression for the rate of heat transfer when radiation shield is introduced between two parallel plates. (06 Marks)

c. Consider two large parallel plates, one at 1000 K with emissivity 0.8 and other is at 300 K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiation shield. (06 Marks)

Module-5

9 a. Write a short note on Aerodynamic heating. (08 Marks)

b. The flow rate of hot and cold fluids running through a parallel flow heat exchanger are 0.2 and 0.5 kg/s respectively. The inlet temperature on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficient on both sides are 650 W/m^2K, calculate the area of heat transfer (for hot and cold fluid, C_p = 4.2 kJ/kg.K) (08 Marks)

OR

10 a. Explain diffusive mass transfer with neat diagram. (08 Marks)

b. Write a short note on Ablative heat transfer. (08 Marks)

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