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B. Tech. EXAMINATION, 2020

(Sixth Semester)

(B Scheme)

(Main & Re-appear)

ME, AER

ME306B

HEAT TRANSFER

Time : 3 *Hours*] [*Maximum Marks :* 75

Before answering the question-paper candidates should ensure that they have been supplied to correct and complete question-paper. No complaint, in this regard, will be entertained after the examination.

Note : Attempt *Five* questions in all, selecting at least *one* question from each Unit. All questions carry equal marks. Use of Fluid Properties and other related Tables, Heisler and Effectiveness Charts is permissible.

Unit I

1. (a) How does the heat conduction differ from convection ? **3**

(b) Define thermal conductivity. How does the thermal conductivity of solid, liquid and gas vary with temperature ? **5**

(c) A horizontal plate (k = 30 W/m-K) 600 mm × 900 mm × 30 mm is maintained at 300°C. The air at 30°C flows over the plate. If the convective coefficient of air over the plate is 22 W/M^2-K and 250 W heat is lost from the plate by radiation, calculate the bottom surface of the plate. **7**

2. (a) Derive general heat conduction equation (three-dimensional) in Cartesian coordinate. **9**

(b) A thick-walled tube of stainless steel with 20 mm inner diameter and 40 mm outer diameter is covered with a 30 mm layer of asbestos insulation (k = 0.2 W/m-K). If the inside wall temperature of the pipe is maintained at 600°C and the outside insulation at 1000°C, calculate the heat loss per meter of length. **6**

Unit II

3. (a) A very long 30 mm diameter copper (k = 380 W/m-K) rod extends from a surface at 120°C. The temperature of surrounding air is 25°C and the heat transfer coefficient over the rod is 12 W/m^{2}K. Calculate : (a) heat loss from the rod and (b) how long the rod should be in order to be considered infinite ? **8**

(b) A solid sphere (k = 39 W/m-K) 10 cm in diameter generates heat at a uniform rate of 5×10^6 W/m^3. The outer surface of the sphere is exposed to an ambient at 50°C with heat transfer coefficient of 400 W/m^2-K. Calculate : (i) maximum temperature in solid and its location (ii) temperature at the radius of 3 cm. **7**

4. (a) What is Biot number ? What is its physical significance ? Is the Biot number more likely to larger for highly conducting solids or insulator one ? **4**

(b) Explain the applications of Heisler and Grober charts in transient heat conduction. A long cylindrical shaft 20 cm in diameter is made of steel (k = 14.9 W/m-K, p = 7900 kg/m^3, C = 477 J/kg-K and $a = 3.97 \times 10^{-6}$ m^2/s). It comes out an oven at a uniform temperature of 600°C. The shaft is then allowed to cool slowly in an environment at 200°C with an average heat transfer coefficient of 80 W/m^2-K. Calculate the temperature at the centre of the shaft, 45 minutes after the start of cooling process. Also calculate the heat transfer per unit length of the shaft during this process. **11**

Unit III

5. (a) A 350 mm long glass plate is hung vetically in the air at 24°C while its temperature is maintained at 80°C. Calculate the boundary layer thickness at the trailing edge of the plate. If a similar plate is placed in a wind tunnel and air is blown over it at a velocity of 5 m/s, find boundary layer thickness at its trailing edge. Also determine the heat transfer coefficient for natural and forced convection for the above-mentioned data. **11**

(b) How is the flow in thermal boundary layer formed over a flat plate ? Differentiate thermal boundary layer and hydrodynamic boundary layer. **4**

6. (a) Discuss the following :

(i) Planck's distribution law

(ii) Wien displacement law

(iii) Kirchhoff's law

(iv) Opaque and white body. **8**

(b) A cubical room 4 m × 4 m × 4 m is heated through the floor by maintaining it at uniform temperature of 350 K, while side walls are well insulated. The heat loss takes place through the ceiling at 300 K. Assuming that all surfaces have an emissivity of 0.8, determine the rate of heat loss by radiation through the ceiling. **7**

Unit IV

7. (a) What are multipass heat exchangers ? When are they used ? **3**

(b) Compare parallel and counter flow heat exchanger. **3**

(c) Derive an expression for effectiveness for an evaporation process. **9**

8. (a) Derive the following relation of boundary layer thickness for laminar film condensation on vertical plate. Mention all assumptions of Nusselt's analysis of film condensation. $\delta = \left[\frac{4\, k\mu\, (t_{sat} - t_s)\, x}{\rho_l\, (\rho_l - \rho_v)\, g\, h_{fg}} \right]^{1/4}$. **11**

(b) Distinguish between nucleate and film boiling. **4**