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10ME63

# Sixth Semester B.E. Degree Examination, June/July 2023
## Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

**Note:** 1. ***Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of heat transfer data handbook is permitted.***



### PART – A

1 a. Briefly explain the three modes of heat transfer. **(06 Marks)**

b. Derive the general three-dimensional conduction equation in Cartesian co-ordinates and state the assumptions made. **(08 Marks)**

c. A wall of furnace is made up of inside layer of Silica brick 120 mm thick covered with a layer of magnesite brick 240 mm thick. The temperature at the inside surface of silica brick wall and outside surface of magnesite brick wall are 725°C and 110°C respectively. The contact thermal resistance between two walls at the interface is 0.0035°C/W per unit wall area. If the thermal conductivities of silica and magnesite bricks are 1.7 W/m°C and 5.8 W/m°C, calculate the temperature drop at the interface. **(06 Marks)**

2 a. Derive an expression for general form of the energy equation for one dimensional heat dissipation from a rectangular fin and state the assumptions made. **(10 Marks)**

b. Two long rods of the same diameter, one made of brass (K= 85 W/m°C) and other made of copper (K = 375 W/m°C) have one of their ends inserted into the furnace. Both the rods are exposed to the same environment. At a distance 105 mm away from the furnace end, the temperature of the brass rod is 120°C. At what distance from the furnace end the same temperature would be reached in the copper rod. **(10 Marks)**

3 a. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped parameter analysis. **(10 Marks)**

b. A Thermo couple junction is in the form of 8 mm diameter sphere. Properties of materials are C = 420 J/kg°C, ρ= 8000 kg/m$^3$, K = 40 W/m°C, h = 40 W/m$^2$°C. This junction is initially at 40°C and inserted in a stream of lid air at 300°C. Find

(i) Time constant of the thermocouple.

(ii) The Thermocouple is taken out from the hot air after 10 seconds and kept in still air at 30°C.

Assuming the heat transfer coefficient in air 10 W/m$^2$°C find the temperature attained by the junction after 20 seconds and when removed from hot air. **(10 Marks)**

4 a. Explain the following with neat sketches:

(i) Velocity boundary layer. (ii) Thermal boundary layer.

(iii) Hydrodynamic Entrance length (iv) Thermal Entrance length. **(12 Marks)**

b. Air at 20°C is flowing over a flat plate which is 200 mm wide and 500 mm long. The plate is maintained at 100°C. Find the heat loss per hour from the plate if the air is flowing parallel to 500 mm side with 2 m/s velocity. The properties of air at $\frac{(100+20)}{2} = 60°C$ are

$\upsilon = 18.97 \times 10^{-6}$ m$^2$/s, K = 0.025 W/m°C and $P_r = 0.7$ **(08 Marks)**

## PART – B

5 a. Using dimensional analysis, obtain fundamental relation between dimensionless parameters in forced convection. **(08 Marks)**

b. A nuclear reactor with its core constructed of parallel plates 2.2 m high and 1.45 m wide have been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960°C, while the lowest temperature is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. For convection co-efficient the appropriate correlation is $Nu = 0.13(Gr\,Pr)^{\frac{1}{3}}$, where the properties at mean film temperature of 650°C for bismuth are $\rho = 10^4$ kg/m$^3$, $\mu = 3.12$ kg/m-h, $C_p = 150.7$ J/kgK. **(12 Marks)**

6 a. Derive an expression for effectiveness of parallel flow heat exchanger. **(08 Marks)**

b. A counter flow heat exchanger is employed to cool 0.55 kg/s ($C_P$ = 2.45 KJ/kg°C) of oil from 115°C to 40°C by the use of water. The inlet and outlet temperatures of cooling water are 15°C and 75°C respectively. The overall heat transfer co-efficient is expected to be 1450 W/m$^2$°C using NTU method calculate, massflow rate of water, Effectiveness and surface area. **(12 Marks)**

7 a. Explain the different regimes of boiling with a neat sketch. **(08 Marks)**

b. Explain the types of condensation with a neat sketch. **(04 Marks)**

c. A vertical tube of 60 mm outside diameter and 1.2 m long is exposed to steam at atmospheric pressure. The outersurface of the tube is maintained at a temperature of 50°C by circulating cold water through the tube. Calculate (i) The rate of heat transfer to the coolant. (ii) The rate of condensation of steam. **(08 Marks)**

8 a. Explain the concept of black body and mention its properties. **(04 Marks)**

b. State and explain Kirchoff's law. **(04 Marks)**

c. Determine heat lost by radiation per meter length of 80 mm diameter pipe at 300°C if,

(i) Located in a large room with red brick walls at a temperature of 27°C.

(ii) Enclosed in a 160 mm diameter red brick conduit at a temperature of 27°C. **(12 Marks)**

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