CBCS SCHEME

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15AU62

Sixth Semester B.E. Degree Examination, Jan./Feb. 2021
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 data hand book is permitted.

Module-1

1 a. Explain briefly:
i) Thermal conductivity
ii) Thermal diffusivity
iii) Overall heat transfer co-efficient
iv) Thermal contact resistance. **(08 Marks)**

b. Derive general heat conduction equation in Cartesian co-ordinates. **(08 Marks)**

OR

2 a. What do you mean by initial conditions and boundary conditions of I, II and III kind. **(08 Marks)**

b. A furnace wall is of thickness 0.25m and is exposed to gas at its inner surface and to air at its outer surface. The gas and air are maintained at 400°C and 50°C. The heat transfer co-efficients of hot gas and cold air sides are 60 and $10 W/m^2.K$ respectively. If the surface area of the wall is $3m^2$. Find:
i) Overall heat transfer co-efficient
ii) The heat transfer rate
iii) The surface temperature of the wall
Assume that the thermal conductivity of the wall material is 1.5W/m.K. **(08 Marks)**

Module-2

3 a. Design critical thickness of insulation and derive an expression for critical thickness of insulation for a cylinder. **(08 Marks)**

b. An iron rod is attached horizontally to a large tank at temperature $T_b = 200°C$. The diameter of the rod (d) is 1cm, length (L) is 30m and thermal conductivity (K) is 65W/m.K. The rod dissipates heat by convection into the ambient air at $T_a = 20°C$, with $h = 15 W/m^2K$. What is the temperature of the rod at 10cm and 20cm from the tank? Calculate the heat transfer rate, the fin efficiency and effectiveness. **(08 Marks)**

OR

4 a. Explain physical significance of Biot number and Fourier number. **(04 Marks)**

b. Obtain an expression for instantaneous heat transfer and total heat trasnfer for lamped heat analysis treatment of conduction problem. **(06 Marks)**

c. A 15mm diameter mild steel sphere K = 42W/mK is exposed to cooling air flow at 20°C. Determine the following:
i) Time required to cool the sphere from 550°C to 90°C.
ii) Instantaneous heat transfer rate 2 minutes after start of cooling. For mild steel $\rho = 7850 kg/m^3$, $c_p = 475 J/kg K$, $\alpha = 0.045 m^2/hr$. **(06 Marks)**

Module-3

5 a. What do you mean by hydrodynamic and thermal boundary layer? (04 Marks)

b. Explain physical significance of

i) Grashoff number

ii) Prandtl number

iii) Nusselt number. (06 Marks)

c. A nuclear reactor with its core constructed of parallel vertical plates 2.2m high and 1.4m wide has been designed on free convection heating of liquid bismuth. The maximum temperature of the plate surface is limited to 960°C while the lowest allowable temperature of bismuth is 340°C. Calculate the maximum possible heat dissipation from both sides of each plate. For the convective co-efficient the appropriate correlation is $N_a = 0.13\,(Gr.Pr)^{0.333}$. (06 Marks)

OR

6 a. With the help of dimensional analysis derive expression which relates Reynolds number, Nusselt number and Prandtl number. (08 Marks)

b. Air at standard conditions of 760mm Hg at 20°C flows over a flat plate at 3m/sec. The plate is 50cms × 25cms. Find the heat lost per hour if air flow is parallel to 50cms side of the plate. If 25cms side is kept parallel to the airflow, what will be the effect on heat transfer? Temperature of the plate is 100°C. (08 Marks)

Module-4

7 a. Derive an expression for effectiveness of a counter flow heat exchanger in terms of number of transfer units (N) and heat capacity ratio of two fluids (C). (08 Marks)

b. Find out the length of tube required for the following heat transfer in a parallel flow heat exchanger where air is heated by exhaust gases Q = 9.3kW, d_i = 5cm, d_o = 6cm, h_i = 116W/m^2 °C, h_o = 186W/m^2 °C. Inlet and outlet temperatures of hot fluid are respectively 400°C and 150°C and for cold fluid are respectively 50°C and 100°C. Neglect the tube resistance. If the flow is made counter flow, what is the percentage of saving in tube length? (08 Marks)

OR

8 a. Explain the different regimes of pool boiling using an appropriate boiling curve. Indicate CHF and Leiden Frost points on it. (08 Marks)

b. A vertical tube of 60mm outside diameter and 1.2m long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 50°C by circulating cold water through the tube. Calculate the following:

i) The rate of heat transfer to the coolant.

ii) The rate of condensation of steam. (08 Marks)

Module-5

9 a. Define emissive power, radiosity, irradiation and surface resistance to radiation. (04 Marks)

b. Explain the physical significance and properties of view factors. (06 Marks)

c. A steam pipe of outer diameter 20cm and length 60cm whose surface is at 200°C passes through a room with wall at 10°C. Assuming that the emissivity of the pipe is 0.8, determine the rate of heat loss from the pipe by radiation. (06 Marks)

OR

10 a. Explain briefly the concept of a black body. (04 Marks)

b. Sketch and explain: i) Kirchoff's law ii) Lambert's cosine law. (04 Marks)

c. Two large parallel plates, with emissivities 0.4 ($\in_1$) and 0.8 ($\in_2$) exchange heat by radiation. If a polished aluminium shield ($\in_3$ = 0.05) is placed between them, calculate the percentage reduction in heat transfer. (08 Marks)

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