CBCS SCHEME

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15ME63

Sixth Semester B.E. Degree Examination, Jan./Feb. 2023
Heat 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 the mechanism of conduction, convection and radiation heat transfer. **(09 Marks)**

b. An exterior wall of a house may be approximated by a 10cm layer of brick (K = 0.7W/m°C), followed by 4cm layer of gypsum plaster (K = 0.48W/m°C). What thickness of rock wool insulation (K = 0.06W/m°C) should be added to reduce the heat loss through the wall by 80%. **(07 Marks)**

OR

2 a. Derive general three dimensional heat conduction equation in Cartesian coordinate system. **(08 Marks)**

b. A square plate heater of size (15 × 15)cm is inserted between two slabs. Slab 'A' is 2cm thick (K = 50W/mK) and slab 'B' is 1cm thick (K = 0.2W/mK). The outside heat transfer co-efficient on both sides of A and B are 200 and 50W/m^2-K respectively. Temperature of surrounding air is 25°C. If the rating of heater is 1kW, find:
i) Maximum temperature in the system.
ii) Outer surface temperature of two slabs. **(08 Marks)**

Module-2

3 a. Derive an expression for critical radius, of insulation for a sphere, hence define the critical thickness of insulation. **(08 Marks)**

b. A steel rod of (12mm × 12mm) with a length of 159mm protrudes into air at 35°C from a furnace wall at 200°C. The thermal conductivity of the material is 51.9W/mK and the convective heat transfer coefficient is 22W/m^{2}K. Determine:
i) The end temperature assuming the end to be insulated.
ii) Temperature at 80mm distance from the wall.
iii) The end temperature, if the fin were to be 80m long with end not insulated. **(08 Marks)**

OR

4 a. Show that the temperature distribution in a body during Newtonian heating or cooling is given by

$$\frac{T - T_\infty}{T_i - T_\infty} = EXP\left[\frac{-hAt}{\rho vcp}\right].$$ **(08 Marks)**

b. A 6cm potato initially at a uniform temperature of 20°C, is suddenly dropped into boiling water at 100°C. The heat transfer co-efficient between water and the surface is 6000W/m^{2}K. The thermo physical properties of potato can be taken same as those of water [$\alpha = 1.6 \times 10^{-7}$m^2/sec and K = 0.68W/m-K]. Determine the time required for the centre of potato to reach 95°C and energy transferred to the potato during this time. **(08 Marks)**

Module-3

5 a. Briefly describe the boundary conditions related to numerical analysis of heat conduction. **(08 Marks)**

b. Explain the energy balance procedure to obtain the finite difference formulation of 1-D heat conduction problem in Cartesian coordinates. **(08 Marks)**

OR

6 a. Define: i) Black body ii) Planck's law iii) Wein's displacement law iv) Lambertz law. **(08 Marks)**

b. Two parallel plates at $T_1 = 900K$ and $T_2 = 500K$ have emissivities $\epsilon_1 = 0.6$ and $\epsilon_2 = 0.9$ respectively. A radiation shield having an emissivity $\epsilon_{31} = 0.15$ on one side and emissivity $\epsilon_{32} = 0.06$. On the other side is placed between the plates. Calculate the percentage reduction in heat transfer, when radiation shield placed between the plates. **(08 Marks)**

Module-4

7 a. Explain the concept of thermal boundary layer on a flat plate. **(08 Marks)**

b. Air at 30°C is flowing across a tube with a velocity of 25m/sec. The tube could be either a square with a side of 5cm or a circular cylinder of diameter 5cm. Compare the rate of heat transfer in each case if the tube surface temperature is 124°C. **(08 Marks)**

OR

8 a. Explain the concept of velocity boundary layer on a flat plate. **(08 Marks)**

b. A circular plate of 25cm diameter with both the surfaces are maintained at a uniform temperature of 100°C is suspended in a horizontal position in atmospheric air at 20°C. Determine the heat transfer from plate. **(08 Marks)**

Module-5

9 a. Derive an expression of LMTD for counter flow heat exchanger. **(08 Marks)**

b. A cross flow heat exchanger with both fluids unmixed is used to heat water flowing at a rate of 20kg/sec from 25°C to 75°C, using gases available at 300°C to be cooled to 180°C. The overall heat transfer coefficient has a value of $95W/m^2$-K. If Cp for gas is 1.005kJ/kg-K. Determine the area of heat transfer required. **(08 Marks)**

OR

10 a. Explain the regimes of pool boiling with a neat sketch. **(08 Marks)**

b. Dry steam at 100°C condenses on outside surface of a horizontal pipe of outside diameter = 2.5cm. The pipe surface is maintained at 84°C by circulating water through it. Determine the rate of formation of condensate per meter length of the pipe. **(08 Marks)**

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