USN | | | | | | | | | | |

15ME63

Sixth Semester B.E. Degree Examination, Jan./Feb. 2021

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 handbook is permitted

Module-1

1 a. Define the following terms: i) Convective heat transfer coefficient ii) Thermal diffusivity iii) Black body iv) Emissivity **(04 Marks)**

b. Consider a one dimensional steady state heat conduction in a plate with constant thermal conductivity in a region $0 \le x \le 1$. A plate is exposed to uniform heat flux 'q' W/M^2 at x = 0 and dissipates heat by convection at x = L with heat transfer coefficient 'h' in the surrounding air at T_∞. Write the mathematical formulation of this problem for the determination of one dimensional steady state temperature. **(04 Marks)**

c. The walls of a house in cold region consists of three layers, an outer brick wall, 15cm thick, an inner wooden panel, 1.2cm thick, the intermediate layer is made of an insulating material, 7cm thick. The thermal conductivities of brick and wood used are 0.7W/mK and 0.18W/mK. The inside and outside temperature of composite wall are 21°C and -15°C. If the layer of insulation offers twice the thermal resistance of the brick wall. Calculate:
i) Rate of heat loss per unit area of wall ii) Thermal conductivity of insulating material. **(08 Marks)**

OR

2 a. Derive three dimensional heat conduction equation in cylindrical coordinate system for a isotropic material. **(08 Marks)**

b. A plane wall 4cm thick has one of its surfaces in contact with a fluid at 130°C with a surface heat transfer coefficient of 250W/m^{2}K and the other surface is in contact with another fluid at 30°C with a surface heat transfer coefficient of 500W/m^{2}K. The thermal conductivity of wall varies with temperature is given by K = 20 (1 + 0.001T), where T is the temperature. Determine the rate of heat transfer through the wall and surface temperatures of the wall. **(08 Marks)**

Module-2

3 a. Obtain an expression for temperature distribution through a rectangular fin when the end of fin is insulated. **(08 Marks)**

b. An electrical cable of 12mm diameter is insulated to increase the current carrying capacity by 15% without increasing the cable surface temperature above 70°C. The ambient air temperature is 30°C. Calculate the conductivity of insulating material required assuming that the heat transfer coefficient on bare and insulated wire is same as 14W/m^{2}K. **(08 Marks)**

OR

4 a. Show that the temperature distribution in a body during Newtonian heating or cooling is given by $\frac{T - T_\infty}{T_i - T_\infty} = e^{-BiFo}$ **(08 Marks)**

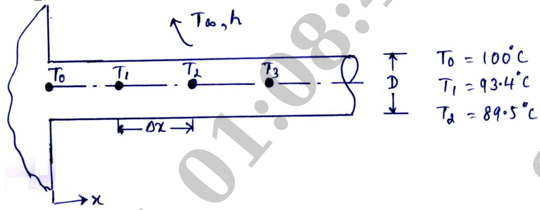
b. A steel cylinder 0.2m diameter and 3m long initially at 500°C is suddenly immersed in a fluid at 40°C. The convective coefficient between the cylinder surface and fluid is 200W/m^{2}K. Assume K = 40W/mK, $\alpha = 1 \times 10^{-5}$m^2/sec. Calculate after 20 minutes i) Temperature at a radius of 0.05m ii) Heat transferred during 20 mins. **(08 Marks)**

Module-3

5 a. Explain Implicit and Explicit method for discretization of 1-dimensional transient heat conduction problem. **(08 Marks)**

b. A steady state, finite difference analysis has been performed on a cylindrical fin with a diameter of 12mm and a thermal conductivity of 15W/mK. The convection process is characterized by a fluid temperature of 25°C and a heat transfer coefficient of 25W/m^{2}K.

Fig.Q.5(b)



i) The temperatures for the first three nodes, separated by a spatial increment of x = 10mm. Determine the fin heat rate.

ii) Determine the temperature at node 3, T3. **(08 Marks)**

OR

6 a. State: i) Kirchoff's law ii) Stefan Boltzman law iii) Wein's displacement law. **(06 Marks)**

b. Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperature of 427°C and 27°C respectively. ε for hot plates is 0.9 and for cold plate is 0.6. If polished aluminium shield is placed between them. Find the percentage reduction in heat transfer ε (shield) = 0.4. **(10 Marks)**

Module-4

7 a. Explain the following:

i) Velocity boundary layer

ii) Thermal boundary layer. **(06 Marks)**

b. Air at 15°C and 1 atmospheric flows over a cylinder of 400mm diameter and 1500mm height at a velocity of 30kM/hr with surface temperature of 45°C. Estimate the rate of heat transfer from the cylinder. **(10 Marks)**

OR

8 a. Obtain fundamental relationship between Nusselt, Prandtl and Grashof numbers applied to natural convection using Buckingham π-theorem. **(08 Marks)**

b. A 350mm long glass plate is hung vertically in the air at 24°C, while its temperature is maintained at 80°C. Calculate the boundary layer thickness at the trailing edge of plate. Also calculate the average heat transfer coefficient over the entire length of plate. **(08 Marks)**

Module-5

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

b. In a double pipe counter flow heat exchanger, 10,000kg/hr of an oil having specific heat of 2095J/kgK is cooled from 80°C to 50°C by 8000 kg/hr of water entering at 25°C. Determine the heat exchanger area for an overall heat transfer coefficient of 300W/m^{2}K. Take specific heat of water as 4180J/kgK. **(08 Marks)**

OR

10 a. Distinguish between the nucleate boiling and film boiling. **(06 Marks)**

b. A tube of 2m length and 25mm outer diameter is to be condense saturated steam at 100°C. While the tube surface is maintained at 92°C. Estimate the average heat transfer coefficient and the rate of condensation of steam if the tube is kept at horizontal. The steam condenses on outside of the tube. **(10 Marks)**

* * * * *