CBCS SCHEME

USN

18MR61

Sixth Semester B.E. Degree Examination, July/August 2022
Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note: ***1. Answer any FIVE full questions, choosing ONE full question from each module.***
2. Heat transfer data book allowed.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Derive general 3 – dimensional heat conduction equation in Cartesian coordinates. **(10 Marks)**

b. A composite wall is made up of three layers of thickness 25cm, 10cm and 15cm of material A, B and C respectively. Thermal conductivities of A and B are 1.65W/mK and 9.2W/mK respectively. The inside is exposed to gases at 1250°C with a convection coefficient of $25 W/m^2K$ and inside surface is at 1100°C. The outside surface is exposed to air at 25°C with convection coefficient $12 W/m^{2}{}^{\circ}C$. Determine :
i) The unknown thermal conductivity 'C'
ii) Overall heat transfer coefficient. **(10 Marks)**

OR

2 a. What do you mean by boundary conditions of 1^{st}, 2^{nd} and 3^{rd} kind? Write mathematical relation for all boundary conditions. **(09 Marks)**

b. Explain briefly :
i) Thermal contact resistance
ii) Thermal diffusivity. **(04 Marks)**

c. It is desired to increase the heat dissipation over the surface of an electronic device of spherical shape of 5mm radius exposed to convection with heat transfer coefficient $h = 10 W/m^2K$ by encasing it in a transparent spherical sheath of K = 0.04W/m K. Determine the diameter of sheath for maximum heat flow for a temperature drop of 120°C from the device surface, determine the heat flow for bare and sheathed device. **(07 Marks)**

Module-2

3 a. Derive an expression for temperature distribution and heat transfer for a pin fin with the tip insulated. **(10 Marks)**

b. A rod (K = 200W/mK), 10mm in diameter and 5cm long has its one end maintained at 100°C. The surface of the rod is exposed to ambient air at 30°C with convective heat transfer coefficient of $100 W/m^2K$. Assuming other end is insulated.
i) The temperature of the rod at 25mm distance from the end at 100°C
ii) Heat dissipation rate from the surface of the rod
iii) Efficiency and effectiveness of fin. **(10 Marks)**

OR

4 a. Show that the temperature distortion under lumped analysis is given by
$$\frac{T - T_{\infty}}{T_0 - T_{\infty}} = e^{-BiFo}$$ **(10 Marks)**

b. A 12cm diameter long bar initially at a uniform temperature of 40°C is placed in a medium of 650°C with a convective coefficient of $22 W/m^2K$ calculate the time required for the bar to reach 255°C. Take K = 20 W/mK; e = 1050J/kg K ; ρ = 580 kg/m³. **(10 Marks)**

Module-3

5 a. Explain the physical significance of :
   i) Nusselt number
   ii) Reynolds number
   iii) Prandtl number
   iv) Grashoff number
   v) Stanton number. **(10 Marks)**

b. Air at atmospheric pressure and 200°C flows over a plate with a velocity of 5m/s. The plate is 15mm wide and is maintained at a temperature of 120°C. Calculate the thickness of hydrodynamic and thermal boundary layer and the local heat transfer coefficient at a distance of 0.5m from the leading edge. Assume that flow is on one side of the plate.
Take : $\rho = 0.815 kg/m^3$; $\mu = 24.5 \times 10^{-6} NS/m^2$; Pr = 0.7 and k = 0.0364W/mK. **(10 Marks)**

OR

6 a. Using dimensional analysis, obtain the dimensionless parameter in free convection heat transfer. **(10 Marks)**

b. A cylindrical body of 300mm diameter and 1.6m height is maintained at a constant temperature of 36.5°C. The surrounding temperature is 13.5°C. Find out the amount of heat to be generated by the body per hour if
$\rho = 1.025 kg/m^3$; $C_P = 0.96 kJ/kg°C$
$\gamma = 15.06 \times 10^{-6} m^2/S$; k = 0.02477W/m°C and
$\beta = \frac{1}{298} k^{-1}$. Assume $Nu = 0.12(Gr.Pr)^{1/3}$. **(10 Marks)**

Module-4

7 a. Derive an expression for LMTD for counter flow heat exchanger. State the assumptions. **(10 Marks)**

b. An oil cooler consist of straight tubes of 2cm OD and 1.5cm ID enclosed with in a pipe and concentric with it. The external pipe is well insulated. The oil flows through the tubes at 0.05kg/s (C_P = 2 kJ/kg°C) and cooling fluid flows in the annulus in opposite direction at the rate of 0.1kg/s (CP = 4kJ/kg°C). The oil enters the cooler at 180°C and leaves at 80°C while cooling liquid enters the cooler at 30°C. Calculate the length of the pipe required if heat transfer coefficient from oil to the tube surface is $1720 W/m^2 °C$ and from metal surface to coolant is $3450 W/m^2 °C$. Neglect the resistance of the tube wall. **(10 Marks)**

OR

8 a. With a neat diagram explain the regins of pool boiling. **(08 Marks)**

b. Differentiate film wise and drop wise condensation. **(04 Marks)**

c. A vertical plate 30cm × 30cm is exposed to steam at atmospheric pressure. The plate temperature is 98°C calculate the heat transferred and mass of steam condensed per hour also determine the film thickness at bottom of plate.
Take thermo physical properties at 99°C are $\rho_e = 960 kg/m^3$; $\mu = 282 \times 10^{-6}$ kg/ms ; K = 0.61W/m°C; h_{fg} = 2255kJ/kg; T_{sat} = 100°C. **(08 Marks)**

Module-5

9 a. State and explain the following :
   i) Stefan Boltzman law
   ii) Kirchhoff's law
   iii) Planks law
   iv) Weins displacement law
   v) Lambert cosine law. **(10 Marks)**

b. Calculate the net radiant heat energy per m^2 area for two large parallel plates at a temperature of 427°C and 27°C respectively. $\in$(hotplate) = 0.9 and $\in$(cold plate) = 0.6. If polished aluminum shield is placed between them, find the percentage reduction in heat transfer. Also determine the temperature of shield, $\in$ = 0.4 for shield. **(10 Marks)**

OR

10 a. For a block body enclosed in a hemispherical space prove that emissive power of the black body is π times the intensity of radiation. **(10 Marks)**

b. An electric heating system is insulated in ceiling of a room 5m × 5m × 205m. The temperature of ceiling is 315K, whereas under equilibrium condition the walls are at 295K. If the floor is non sensitive to radiation and emissivities of the ceiling and wall are 0.75 and 0.65 respectively calculate the radiant heat loss from the ceiling of wall. **(10 Marks)**

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