

# CBCS SCHEME

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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.

### 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 25W/m<sup>2</sup>K and inside surface is at 1100°C. The outside surface is exposed to air at 25°C with convection coefficient 12W/m<sup>2</sup>°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<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> 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  $h = 10\text{W/m}^2\text{K}$  by encasing it in a transparent spherical sheath of  $K = 0.04\text{W/m K}$ . 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 ( $K = 200\text{W/mK}$ ), 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 100W/m<sup>2</sup>K. 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<sup>2</sup>K calculate the time required for the bar to reach 255°C. Take  $K = 20\text{ W/mK}$ ;  $e = 1050\text{J/kg K}$ ;  $\rho = 580\text{ kg/m}^3$ . (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 :  $\rho = 0.815 \text{ kg/m}^3$ ;  $\mu = 24.5 \times 10^{-6} \text{ NS/m}^2$ ;  $\text{Pr} = 0.7$  and  $k = 0.0364 \text{ W/mK}$ . (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  
 $\rho = 1.025 \text{ kg/m}^3$ ;  $C_p = 0.96 \text{ kJ/kg}^\circ\text{C}$   
 $\gamma = 15.06 \times 10^{-6} \text{ m}^2/\text{S}$ ;  $k = 0.02477 \text{ W/m}^\circ\text{C}$  and  
 $\beta = \frac{1}{298} \text{ K}^{-1}$ . Assume  $\text{Nu} = 0.12(\text{Gr.Pr})^{1/3}$ . (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 ( $C_p = 2 \text{ kJ/kg}^\circ\text{C}$ ) and cooling fluid flows in the annulus in opposite direction at the rate of 0.1kg/s ( $C_p = 4 \text{ kJ/kg}^\circ\text{C}$ ). 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  $1720 \text{ W/m}^2^\circ\text{C}$  and from metal surface to coolant is  $3450 \text{ W/m}^2^\circ\text{C}$ . 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  $\rho_e = 960 \text{ kg/m}^3$ ;  $\mu = 282 \times 10^{-6} \text{ kg/ms}$  ;  
 $K = 0.61 \text{ W/m}^\circ\text{C}$ ;  $h_{fg} = 2255 \text{ kJ/kg}$ ;  $T_{\text{sat}} = 100^\circ\text{C}$ . (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  $\text{m}^2$  area for two large parallel plates at a temperature of  $427^\circ\text{C}$  and  $27^\circ\text{C}$  respectively.  $\epsilon(\text{hotplate}) = 0.9$  and  $\epsilon(\text{cold plate}) = 0.6$ . If polished aluminum shield is placed between them, find the percentage reduction in heat transfer. Also determine the temperature of shield,  $\epsilon = 0.4$  for shield. (10 Marks)

**OR**

- 10 a. For a black body enclosed in a hemispherical space prove that emissive power of the black body is  $\pi$  times the intensity of radiation. (10 Marks)
- b. An electric heating system is insulated in ceiling of a room  $5\text{m} \times 5\text{m} \times 205\text{m}$ . The temperature of ceiling is  $315\text{K}$ , whereas under equilibrium condition the walls are at  $295\text{K}$ . 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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