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Sixth Semester B.E. Degree Examination, June/July 2025
Heat Transfer

Time: 3 hrs. Max. Marks: 100

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. State and explain governing laws of conduction, convection and radiation. **(06 Marks)**

b. Write a note on thermal conductivity of solids, liquids and gases. **(06 Marks)**

c. A heat exchanger wall consists of a copper plate 2 cm thick. The heat transfer coefficients on the two sides of the plate are 2700 and 7000 W/m^2K, corresponding to fluid temperatures of 92°C and 32°C respectively. Assuming that the thermal conductivity of the wall is 375 W/mK. Compute the surface temperatures and the heat flux in W/m^2. **(08 Marks)**

OR

2 a. Derive an equation for critical thickness of insulation in a cylinder. **(06 Marks)**

b. Explain the 1^{st} and 2^{nd} types of boundary conditions applied to heat conduction problems. **(04 Marks)**

c. A composite refrigerator wall is composed of 5 cm of cork board sandwiched between a 1.2 cm thick layer of Oak and a 0.8 mm thickness of aluminium lining on the inner surface. The average convective heat transfer coefficients at the interior and exterior wall are 11 and 8.5 W/m^2K respectively.

i) Draw the thermal circuit

ii) Calculate overall heat transfer coefficient

iii) For an air temperature inside the refrigerator of -1°C and outside of 32°C calculate the rate of heat transfer per unit area through the wall. **(10 Marks)**

Module-2

3 a. Obtain an expression for temperature distribution and heat flow through a fin of uniform cross section with the end insulated. **(10 Marks)**

b. Define effectiveness of fins. **(02 Marks)**

c. The alluminium square fins (0.5 mm × 0.5 mm), 10 mm long are provided on the surface of semi conductor electronic device to carry 1 watt of energy generated. The temperature at the surface of the device should not exceed 80°C, when the surrounding temperature is 40°C. K for aluminium is 200 W/m°C and h is 15 W/m^2°C. Determine the number of fins required to carry out the above duty. Neglect the heat loss from the end of the fin. **(08 Marks)**

OR

4 a. What is Lumped analysis? Derive an expression for temperature distribution and rate of heat transfer in case of Lumped system analysis. **(08 Marks)**

b. Explain the significance of Biot number and Fourier number in transient heat conduction. **(04 Marks)**

c. A steel ball 5 cm diameter and initially at 900°C is placed in still air at 40°C. Find :

i) Temperature of ball after 30 seconds.

ii) The rate of cooling in °C/min after 30 seconds.

Assume $h = 20\ W/m^2{}^\circ C$, $K_{steel} = 40\ W/m^\circ C$, $\rho_{steel} = 7800\ kg/m^3$, $C_{p_{steel}} = 460 J/kgK$. **(08 Marks)**

Module-3

5 a. Explain the three types of boundary conditions applied in Finite difference method. **(08 Marks)**

b. Define Stefan Boltzman law and Kirchoff's law for radiation heat transfer. **(04 Marks)**

c. Determine the temperature at the four nodes as shown in Fig.Q.5(b). Assume steady state two dimensional heat conduction. The four faces of the square shape are each at different temperatures. Solve by completing 4 iterations. **(08 Marks)**

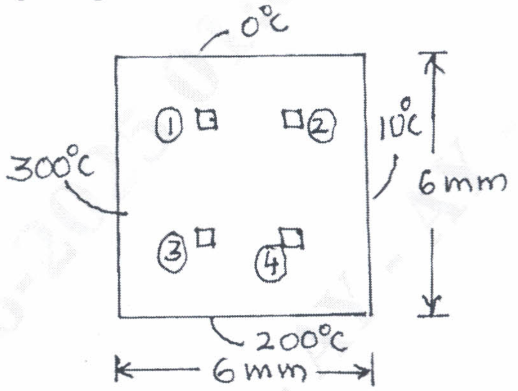

Fig.Q.5(c)

OR

6 a. Define :
- i) Black body
- ii) Wein displacement law
- iii) Lamberts law
- iv) Planks law **(08 Marks)**

b. Explain :
- i) Specular (Radiation) Reflection
- ii) Diffuse Reflection. **(04 Marks)**

c. Two large parallel plates with $\in = 0.5$ each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiation shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(08 Marks)**

Module-4

7 a. What is the physical significance of the Nusselt number and Grashoff number? **(04 Marks)**

b. By dimensional analysis show that for free convection heat transfer nusselt number can be expressed as a function of prandtl number and Grashof number. **(08 Marks)**

c. A vertical cylinder 1.8 m height, 7.5 cm in diameter is maintained at a temperature of 90°C in an atmospheric environment of 30°C. Calculate the heat loss by free convection from this cylinder. The cylinder may be treated as vertical plate. **(08 Marks)**

OR

8 a. What is the physical significance of the Reynold number and Prandtl number? **(04 Marks)**

b. Explain the concept of hydrodynamic and thermal boundary layer. **(08 Marks)**

c. Water flows with a velocity of 0.6 m/s through a tube of inside diameter 60 mm and length 3.5 m. Find the heat transfer rate by forced convection. Mean water temperature is 50°C and tube wall surface temperature is 70°C. **(08 Marks)**

Module-5

9 a. Write a note on classification of heat exchangers. **(04 Marks)**

b. Derive an expression for effectiveness of heat exchanger for parallel flow heat exchanger. **(08 Marks)**

c. Exhaust gases from a power plant are used to pre heat air in a cross flow heat exchanger. The exhaust gases enter the heat exchanger at 450°C and leave at 200°C. The air enters the heat exchanger at 70°C, leaves at 250°C and has a mass flow rate of 10 kg/s. Assume the properties of exhaust gases can be approximated by those of air. The over all heat transfer coefficient of the heat exchanger is 154 W/m^2K. Calculate the heat exchanger surface area required if the air is unmixed and the exhaust gases are mixed. **(08 Marks)**

OR

10 a. Clearly explain the regions of pool boiling with neat sketch. **(08 Marks)**

b. Define critical heat flux. Explain what happens if you continue heat transfer beyond critical point. **(04 Marks)**

c. A 8 mm diameter metal clad heating element is horizontally immersed in water bath. The surface temperature of the metal is 250°C under steady state conditions. Estimate the power dissipation per unit length of the heater. **(08 Marks)**

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