

Heat Transfer Operation (ICH- 502) (1st CT); date 26-10-2024

1. Derive an expression for one dimensional heat conduction equation for long cylinder. (5)
2. Explain about the fins and their types and derive an expression for infinitely long fin. (5)
3. Explain the concept of hydrodynamic boundary layer (5)
4. Consider a 0.8m high and 1.5m wide glass window with a thickness of 8mm and  $K = 0.78\text{W/Mk}$ . Determine the steady rate of heat transfer through this glass window and the temperature of its inner surface for a day during which the room is maintained at  $20^{\circ}\text{C}$  while the temperature of the outdoors is  $-10^{\circ}\text{C}$ . Take  $h_1 = 10\text{ W/Mk}$ ,  $h_2 = 40\text{W/mK}$ . (5)

**B.Tech.****(SEM III) ODD SEMESTER EXAMINATION 2024-25****HEAT TRANSFER OPERATION**

[TIME: 3 hrs.]

[Max. Marks: 70]

Note: Attempt All Questions. All Question carry equal marks.

**Q1. Answer ALL parts.**

- (a) What is fourier's law of heat conduction
- (b) How the conduction take places in different phases.
- (c) Explain the thermal conductivity with unit.

Marks

3.5

3.5

3.5

**OR**

- (d) Explain the thermal diffusivity with unit
- Derive an expression for conduction through plane wall in series or plane composite wall.

3.5

**OR**

The walls of a house in a cold region consist of three layer – an outer brickwall of 15 cm thickness and inner wooden panel wall of 1.2 cm thickness. The intermediate layer is made of an insulating material 7 cm thick. The thermal conductivity of the brick and the wool used  $0.70 \text{ W/m}^\circ\text{C}$  and  $0.18 \text{ W/m}^\circ\text{C}$  respectively. The inside and outside temperature of the composite wall are  $21^\circ\text{C}$  and  $-15^\circ\text{C}$ , respectively. If the layer of insulation offers twice the thermal resistance of the brick wall, calculate (A) the rate of heat loss per unit area of the wall.

**Q2. Answer ALL parts.**

- (a) How does a fin enhance heat transfer at a surface? mention the common types of fins and discuss the comparative advantages of fins of different geometries.
- (b) Explain the analogies between momentum and heat transfer.

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**OR**

A thick-walled tube of stainless steel (A) having a  $k = 21.63 \text{ W/m.K}$  with dimensions of  $0.0254 \text{ m}$  ID and  $0.0508 \text{ m}$  OD is covered with a  $0.0254 \text{ m}$  layer of asbestos (B) insulation,  $k = 0.2423 \text{ W/m.K}$ . The inside wall temperature of the pipe is  $811 \text{ K}$  and the outside surface of the insulation is at  $310.8 \text{ K}$ . for a  $0.305 \text{ m}$  length of pipe, calculate the heat loss and also the temperature at the interface between the metal and the insulation.

**Q3. Answer ALL parts.**

- (a) Explain the Wein's displacement law and derive it from planck's law

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**OR**

Classify different types of evaporators. What are calandria and propeller calandria.

- (b) Consider a  $20\text{cm}$  diameter spherical ball at  $800\text{K}$  suspended in air. assuming the ball closely approximates a blackbody determine (a) the total blackbody emissive power (b) the total amount of radiation emitted by the ball in  $5 \text{ min}$  (c) the spectral blackbody emissive power at a wavelength of  $3 \text{ micron}$ .

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**Q4. Answer ALL parts.**

- (a) What are the different boiling regimes? Define critical heat flux and boiling crisis.

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- (b) Explain the terms  
Film wise condensation with diagram  
Drop wise condensation with diagram

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OR

The water is to be boiled at atmospheric pressure in a mechanically polished stainless steel pan placed on top of a heating unit. The inner surface of the bottom of the pan is maintained at 10C. If the diameter of the bottom of the pan is 30cm, determine the rate of heat transfer to the water and the rate of evaporation of water.  
Saturation temperature 100 °C,  $\sigma = 0.0589\text{N/m}$ ,  $h_{fg} = 2257 \times 10^3 \text{ J/kg}$ ,  $\rho_v = 0.6\text{kg/m}^3$ ,  $\rho_l = 957.9 \text{ kg/m}^3$ ,  $\mu_l = 0.282 \times 10^{-3} \text{ kg/ms}$ ;  $Pr_l = 1.75$ ;  $C_{pl} = 4217\text{J/Kg.K}$ ,  $C_{sf} = 0.0130$

Q5. Answer ALL parts.

(a) In the heat transfer relation  $Q = UA\Delta T_{lm}$  for heat exchanger, what is  $\Delta T_{lm}$  called? how is it calculated for a parallel flow and counter flow heat exchanger.

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(b) What is the role of the baffles in a shell and tube heat exchanger? How does the presence of baffles affect the heat transfer and the pumping power requirements? explain.

OR

Cold water enters a counter flow heat exchanger at 10 °C at a rate of 8 kg/s, where it is heated by a hot water stream that enters the heat exchanger at 70 °C at a rate of 2kg/s. Assuming the specific heat of water remain constant at  $C_p = 4.18 \text{ KJ/kg.K}$ , Determine the maximum heat transfer rate and the outer temperature of the cold and the hot water streams for this limiting case.