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18AU62

Sixth Semester B.E. Degree Examination, Jan./Feb. 2023
Heat and Mass 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 hand book is permitted.

Module-1

1 a. Explain briefly the mechanism of conduction convection and radiation of heat transfer. **(06 Marks)**

b. Derive the general three dimensional heat conduction equation in Cartesian co-ordinate and state the assumptions made. **(08 Marks)**

c. A mild steel tank of wall thickness 20mm is used to store water at 95°C. Thermal conductivity of mild steel is 45W/m-K and the heat transfer co-efficient inside and outside the tank are 2850W/m^{2}K and 10W/m^{2}K respectively. If surrounding air temperature 20°C, calculate rate of heat transfer per unit area of the tank. **(06 Marks)**

OR

2 a. Explain briefly: i) Thermal conductivity ii) Overall heat transfer co-efficient. **(04 Marks)**

b. Explain the three types of boundary conditions used in conduction heat transfer. **(06 Marks)**

c. The wall of a house in cold region consists of three layers, an outer brick work 15cm thick, the inner wooden panel 1.2cm thick, the intermediate layer is insulator of 7cm thick. The thermal conductivity for brick and wood are 0.7 and 0.18W/mtr. The inside and outside temperature of wall are 21 and -15°C. If insulation layer offer twice the thermal resistance of the brick wall. Calculate: i) Heat loss per unit area ii) Thermal conductivity of insulator. **(10 Marks)**

Module-2

3 a. Derive the expression for critical thickness of insulation for cylinder. **(06 Marks)**

b. Differentiate between effectiveness and efficiency of fins. **(04 Marks)**

c. A steel rod (K = 30W/mk) 1cm diameter and 5cm long with insulation end is to be used as a spine. If is exposed to the surrounding temperature of 65°C and heat transfer coefficient of 50W/m^{2}K. The temperature of the base is 98°C. Determine: i) Fin efficiency ii) Temperature at the end of spine iii) Heat dissipation from spine. **(10 Marks)**

OR

4 a. Derive the expression for temperature variation and heat flow using lumped parameter analysis. **(08 Marks)**

b. Explain significance of Biot and Fourier number. **(04 Marks)**

c. The average heat transfer coefficient for flow of 100°C air over a flat plate is measured by observing the temperature time history of a 3cm thick copper slab exposed to 100°C air, in one test run, the initial temperature of slab was 210°C and in 5 min the temperature is decreased by 40°C. Calculate heat transfer coefficient for this case. Assume ρ = 9000kg/m^3, C = 0.38kJ/kg K, K = 370W/m-K. **(08 Marks)**

Module-3

5 a. Explain with neat sketches i) Velocity boundary layer ii) Thermal boundary layer. **(10 Marks)**

b. Air flows over a flat plate at 30°C, 0.4m wide and 0.75m long with a velocity of 20m/s. Determine the heat transfer from the surface of plate assuming plate is maintained at 90°C.
Use: $Nu_L = 0.664\ R_e^{0.5}\ Pr^{0.33}$ for laminar.

$Nu_L = [0.036\,R_e^{0.8} - 0.836]\,Pr^{0.333}$ for turbulent. **(10 Marks)**

OR

6 a. Explain the physical significance of the following dimensionless number:
i) Reynold's number
ii) Prandtl number
iii) Nusselt number
iv) Stanton number
v) Grashoff number. **(10 Marks)**

b. A steam pipe 5cm in diameter is lagged with insulating material of 2.5cm thick. The surface temperature is 80°C. Find the total heat loss by natural convection. The temperature of the air surrounding the pipe is 20°C. **(10 Marks)**

Module-4

7 a. Derive expression for LMTD for parallel flow heat exchanger and state the assumption made. **(10 Marks)**

b. Water enters a counter flow heat exchanger at 15°C flowing at a rate of 1300kg/h. It is heated by oil [C_p = 2000J/kg K] flowing at the rate of 550kg/h with an inlet temperature of 94°C for an area 1m^2 and overall heat transfer coefficient of 1075W/m^{2}K. Determine the total heat transfer and outlet temperature of water and oil. **(10 Marks)**

OR

8 a. Explain different regimes of pool boiling with neat sketches. **(10 Marks)**

b. Saturated steam at a temperature of 85°C condenses on the outer surface of 256 horizontal tubes each of outer diameter 1.3cm and arranged in a 16 × 16 array. Tube surfaces are maintained at a uniform temperature of 75°C. Determine the total condensate rate based on Nusselt theory. **(10 Marks)**

Module-5

9 a. Define the terms used in radiation heat transfer with appropriate diagram:
i) Absorptivity ii) Transmissivity iii) Reflectivity iv) Black body v) Opaque body. **(10 Marks)**

b. Two large parallel plates with $\varepsilon = 0.5$ each are maintained at different temperatures and are exchanging heat only by radiation. Two equally large radiators shields with surface emissivity 0.05 are introduced in parallel to the plates. Find the percentage reduction in net radiative heat transfer. **(10 Marks)**

OR

10 a. Briefly explain the following:
i) Kirchoff's law
ii) Stefan-Boltzmann law
iii) Wein's displacement law
iv) Lamberts law
v) Planks law. **(10 Marks)**

b. The temperature of black surface of 0.2m^2 area is 540°C. Calculate: i) The total rate of energy emission ii) The intensity of normal radiation iii) The wavelength of maximum monochromatic emission power. **(10 Marks)**

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