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18ME63

Sixth Semester B.E. Degree Examination, June/July 2023
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 Thermodynamic and Heat Transfer data hand book is permitted.*
3. *Any missing data can be suitably assumed.*

Module-1

1 a. With usual notations, starting from 3-dimesional conduction equation, derive one dimensional equation in rectangular coordinates. **(10 Marks)**

b. Explain the different boundary conditions as applicable to heat transfer analysis. **(10 Marks)**

OR

2 a. What is critical thickness of insulation? Derive an expression for critical radius of insulation interms of thermal conductivity and HTC 'h'. **(10 Marks)**

b. A furnace wall is made up of inside silica brick (K = 1.856 W/m-K) and outside magnesia brick (K = 5.568 W/m-K) each 10 mm thick. If inner and outer surface temperature of wall are 820°C and 120°C. Find the heat flow rate through the plane Wall/m^2. Take the contact resistance of 1.722×10^{-3} m^2-K/W. Also find the interface temperature. **(10 Marks)**

Module-2

3 a. With usual notations, derive an expression for temperature distribution for infinite Fin. State the assumptions made. **(10 Marks)**

b. Find the amount of heat transfer through iron fin of thickness 5 mm, height 50 mm and width 100 cm. Take atmospheric temperature as 28°C and K = 50 W/m-K. The HTC = 10 W/m^2-K the temperature difference at the base of the fin = 80°C. Estimate the efficiency of the fin. **(10 Marks)**

OR

4 a. With usual notations derive an expression for temperature distribution through a body for lumped parameter analysis in terms of Biot number and Fourier number. **(10 Marks)**

b. Mild Steel Sphere of 15 mm dia initially at 625°C is exposed to current of air at 25°C with HTC h = 120 W/m^2-K. Calculate:
(i) Time required to cool the sphere to 100°C
(ii) Initial rate of cooling in °C/sec.
(iii) Total energy removed for one minute. The thermophysical properties for MS are K = 43 W/m-K, C = 474 W/m-K, ρ = 7850 kg/m^3 and α = 0.045 m^2/sec. **(10 Marks)**

Module-3

5 a. Write a note on spectral and total emissive power of a body. **(08 Marks)**

b. Write a short note on the concept of black body and grey body. **(04 Marks)**

c. The average solar radiation flux on the earth's atmosphere is 1353 W/m^2. Calculate the temperature of sun (a black body) having diameter 1.392×10^6 km and has a mean distance of 1.496×10^8 km from the earth's atmosphere. State any assumption made. **(08 Marks)**

OR

6 a. Explain Wein's displacement law, Kirchoff's law and Max Plank's law. (10 Marks)

b. Two large parallel planes with emissivity of 0.6 are at 900 K and 300 K. A radiation shield with one side polished and having emissivity of 0.05, while the emissivity of other side is 0.4 is proposed to used. Which side of the shield to face the hotter plane, if the temperature of shield is to kept minimum? Comment on your answer. (10 Marks)

Module-4

7 a. Explain the concept of development of boundary layer over a flat plate with different zones. (10 Marks)

b. Atmospheric air at 2°C and free stream velocity of 20 m/s flows over 1.5 m long flat plate maintained at uniform temperature of 88°C. Calculate:
(i) The average HTC 'h' over the region of laminar boundary layer.
(ii) Average H.T.C. (Heat Transfer Coefficient) for entire length of plate 1.5 m.
(iii) Total Heat Transfer Rate. Take critical Reynolds number $Re_c = 2 \times 10^5$. (10 Marks)

OR

8 a. Explain the significance of Reynolds number, Prandtl Number, Nusselt number and Grasshof number with equations. (10 Marks)

b. Calculate the total heat loss from a human body, assuming as vertical cylinder, 30 cm in dia and 175 cm in height stand in still air at 13°C. Take the skin temperature as 37°C and emissivity as 0.4. (10 Marks)

Module-5

9 a. Define heat exchanger and classify them. (04 Marks)

b. Derive an expression for Lag Mean Temperature Difference (LMTD) for counter flow heat exchanger. State the assumptions made. (08 Marks)

c. A heat exchanger is required to cool 55000 kg/hr of alcohol from 66°C to 40°C using 44,000 kg/hr of water entering at 5°C. Calculate:
(i) Exit temperature of water
(ii) Heat transfer
(iii) Surface area required for parallel flow and counter flow type heat exchanger design and comment on the results overall HTC U = 580 W/m^2-K, $C_{p(alcohol)}$ = 3760 J/kg-K, $C_{p(water)}$ = 4180 J/kg-K. (08 Marks)

OR

10 a. Define film wise and drop wise condensation process. (04 Marks)

b. With a neat sketch, explain the modes of pool boiling. (08 Marks)

c. Steam at 0.065 bar condenser on a vertical plate 0.6 m square. If the surface temperature of the plate is maintained at 15°C, estimate the rate of condensate. The properties of condensate at mean temperature 26.4°C are, $\rho = 1000$ kg/m^3, $\mu = 864 \times 10^{-6}$ N-S/m^2, K = 0.913 W/m-K., $h_{fg(latent\ heat)} = 2412 \times 10^3$ J/kg-K. (08 Marks)

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