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Sixth Semester B.E. Degree Examination, June/July 2024
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 handbook is permitted.*

Module-1

1 a. What are the three modes of Heat transfer? Write governing equations for these modes. **(06 Marks)**

b. Explain with example, combined correction and radiation. **(06 Marks)**

c. A wire of 0.5mm diameter is stretched along the axis of cylinder 50mm in diameter and 250mm long. The temperature of the wire is 750K while the cylinder is at 250K and the gas in it has K = 0.00251W/mK. Find the rate of heat transfer through the gas by conduction and by radiation, if the wire is black. **(08 Marks)**

OR

2 a. Derive the three dimensional heat conduction equation in Cartesian co-ordinates. **(06 Marks)**

b. Explain the concept of i) Thermal resistance ii) Thermal contact resistance. **(06 Marks)**

c. A furnace wall has inside surface temperature of 1100°C where the ambient air temperature is 25°C. Wall consist of 125mm thick refractory bricks (K = 1.6W/mK) and 125mm thick fire bricks (K = 0.3W/mK) and 12cm thick plaster (K = 0.14 W/mK). There is an air gap which offers a thermal resistance of 0.16K/w. The heat transfer coefficient on the outside wall to air is 17W/m^2 K. Find i) The rate of heat loss per unit area of wall surface
ii) Interface temperature throughout the wall and
iii) Temperature of outside surface of wall. **(08 Marks)**

Module-2

3 a. A tube 2cm OD maintained at uniform temperature of T_i is covered with insulation (K = 0.2W/mK) to reduce heat loss to ambient air at T_∞ with h_o = 15W/m^2K. Find
i) Critical thickness of insulation ii) Rate of heat loss form the tube with insulation to that without insulation.
(a) If the thickness is equal to r_c (b) If the thickness of insulation is (r_c +2)cm. **(10 Marks)**

b. Derive the general solution for temperature distribution for a fin. **(10 Marks)**

OR

4 a. A bar of square cross section connects two metallic structures. One structure is maintained at a temperature of 200°C and the other is maintained at 50°C. The bar 20mm × 20mm is 100mm long and is made of mild steel (K = 0.06kW/mK). The surroundings are at 20°C and the heat transfer coefficient between the bar and the surrounding is 0.01kW/m^2 K. Derive the equation for the temperature distribution along the bar and hence calculate the total heat flow rate from the bar to the surroundings. **(08 Marks)**

b. Derive the expression for temperature distribution for bodies of infinite thermal conductivity by lumped capacitance method. **(06 Marks)**

c. What is Hester's chart and position correction chart? Explain. **(06 Marks)**

Module-3

5 a. What is Critical Reynolds number for flow over a flat plate? On what does it depend. **(06 Marks)**

b. What is Reynold's – Colburn Anology? Explain. **(06 Marks)**

c. It was found during a test in which water flowed with a velocity of 2.44m/s through a tube (2.54cm inner diameter and 6.08m long), that the head loss due to friction was 1.22m of water. Estimate the surface heat transfer coefficient based on Reynold's analogy. Take $\rho = 998$ kg/m^3 and $C_p = 4.187$ kJ/kg K. **(08 Marks)**

OR

6 a. Show that for laminar flow of air (Pr = 0.714), the load and average values of Nusselt number for natural convection heat transfer from or to a vertical plat are given by $Nu_x = 0.378\, Gr^{1/4}$ or $\overline{N}u_L = 0.504\, Gr_2^{1.4}$. **(10 Marks)**

b. Given that A 0.15m o.d steel pipe lies 2m vertically and 8m horizontally in a large room with an ambient temperature of 30°C. The pipe surface is at 250°C and has emissivity 0.60. Estimate total rate of heat loss from the pipe to the atmosphere. **(10 Marks)**

Module-4

7 a. Show that for parallel flow heat exchanger

$$\Sigma = \frac{1-\exp[-NTU(1+R)]}{1+R}.$$ **(08 Marks)**

b. A counter flow heat exchanger is to heat air entering at 400°C with flow rate of 6kg/s by the exhaust gas entering at 800°C with a flow rate of 4kg/s. The overall heat transfer coefficient is 100 Watts/m^2 K and outlet temperature of air is 551.5 °C. Specific heat of air, Cp for both air and exhaust gas can be taken as 1100J/kg K. Calculate i) the heat transfer area needed and ii) the number of transfer units. **(08 Marks)**

c. Explain Storage type heat exchanges. **(04 Marks)**

OR

8 a. What is Nucleate boiling? Explain critical heat flux. **(08 Marks)**

b. What is meant by drop wise and film wise condensation? **(04 Marks)**

c. A tube of 15mm outside diameter and 1.5m long is used for condensing steam at 40Kpa. Calculate average heat transfer coefficient when the tube is i) Horizontal ii) Vertical and its surface temperature is maintained at 50°C. **(08 Marks)**

Module-5

9 a. Derive Weins displacement law. $\lambda_{max} T = 2.898 \times 10^{-3}$mK from Planck's equation. **(06 Marks)**

b. Explain Intensity of radiation and Shape factor. **(08 Marks)**

c. A black body emits radiation at 2000K. Calculate i) the monochromatic emissive power at 1μm wave length ii) wavelength at which emission is maximum and iii) the maximum emissive power. **(06 Marks)**

OR

10 a. Derive expression for view factor for radiation between parallel gray planes. **(08 Marks)**

b. The distance of Sun form Earth is 150×10^6 km. If the radius of the Sun is 0.7×10^6 km and its temperature is 6200K, estimate the mean temperature of Earth. Assume that the rate of radiators heat transfer from the Sun to the Earth is equal to the radiant transfer from the Earth to the outer space which is at 0 K. Consider the Earth and Sun as black. **(08 Marks)**

c. What is Radiation Shield? Explain. **(04 Marks)**

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