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10ME63

Sixth Semester B.E. Degree Examination, June / July 2013

Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting atleast TWO question from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. 2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART - A

1 a. Write down 3 – dimensional conduction equation in Cartesian coordinates. Explain the meaning of each term. **(06 Marks)**

b. What do you mean by initial conditions and boundary conditions of I, II & III kind? **(06 Marks)**

c. A composite wall consists of 10cm layer of building brick (0.7W/m^{0}C) and 3cm plaster (0.5W/m^{0}C). An insulating material of K = 0.08 W/m^{0}C is to be added to reduce the heat transfer through the wall by 70%. Determine the thickness of insulating layer. **(08 Marks)**

2 a. Obtain an expression for heat transfer through a plane wall in which thermal conductivity is given by $K = K_0(1+\alpha T)$, where α is constant, K_0 thermal conductivity at reference temperature T is the temperature. **(06 Marks)**

b. Derive an expression for critical thickness of insulation for a cylinder. **(06 Marks)**

c. A wire of 8mm diameter at a temperature of 60^{0}C is to be insulated by a material having K = 0.174W/m ^{0}C. Heat transfer coefficient h_a = 8W/m^{2}K and ambient temperature T_a = 25^{0}C. For max heat loss find the minimum thickness of insulation. Find increase in heat dissipation due to insulation. **(08 Marks)**

3 a. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment heat conduction problems. **(08 Marks)**

b. Explain physical significance of Biot and Fourier numbers. **(06 Marks)**

c. A household electric Iron (ρ = 2700 kg/m^3, C_p = 0.896 kJ/kg K and K = 200W/m^{0}C) and weighs 1.5 kg. The total area of iron is 0.06m^2 and it is heated with 500W heating element. Initially the iron is at 25^{0}C (ambient Tempr). How long it takes for the iron to reach 110^{0}C. Take h_a = 15W/m^{2}K. **(06 Marks)**

4 a. Define Hydrodynamic and thermal Boundary layer incase of flow over a flat plate. **(06 Marks)**

b. An appropriate expression for temperature profile in thermal boundary layer is given by :

$$\frac{T_{(x,y)} - T_w}{T_\infty - T_w} = \frac{3}{2}\frac{y}{\delta_t(x)} - \frac{1}{2}\left(\frac{y}{\delta_t(x)}\right)^3, \text{ where } \delta_{t(x)} = 4.53\frac{x}{R_{ex}^{1/2}\ P_\gamma^{1/3}}.$$

Develop an expression for local heat transfer coefficient $h_{(x)}$. **(06 Marks)**

c. A vertical pipe 15cm OD, 1m long has a surface temperature of 90^{0}C. If the surrounding air is at 30^{0}C. What is the rate of heat loss by free convection? **(08 Marks)**

PART - B

5 a. Using dimensional analysis, obtain a relation between N_u, R_e and P_r for forced convection heat transfer. **(10 Marks)**

b. Air flows over a flat plate at 30^{0}C, 0.4m, 0.75m long with a velocity of 20m/s. Determine the heat transfer from the surface of plate assuming plate is maintained at 90^{0}C. Use

$Nu_L = 0.664\ R_e^{0.5}\ Pr^{0.33}$ for laminar

$= [0.036\ R_e^{0.8} - 836]P_r^{0.333}$. **(10 Marks)**

6 a. Derive an expression for effectiveness of parallel flow heat exchanger. **(08 Marks)**
b. Under what conditions LMTD and effectiveness methods are used in the design of heat exchanger. **(02 Marks)**
c. Oil at 100^0C (C_P = 3.6kJ/kg K) flows at a rate of 30,000 kg/hr and enters a parallel flow heat exchanger. Cooling water (C_P = 4.2kJ/kg K) enters heat exchanger at 10^0C at the rate of 50,000kg /hr. The heat transfer area is $10m^2$ and u = $1000W/m^2K$. Calculate outlet temperature of oil and water. **(10 Marks)**

7 a. With neat sketch, explain the regions of pool boilding. **(08 Marks)**
b. State and explain Fick's law of diffusion. **(04 Marks)**
c. Dry saturated steam at atmospheric pressure condenses on a vertical tube of diameter 5cm and length 1.5m. If the surface is maintained at 80^0C, determine the heat transfer rate and the mass of steam condensed per hr. **(08 Marks)**

8 a. Define : **(08 Marks)**
i) Black body ii) Plank's law iii) Wein displacement law iv) Lambert's law.
b. Prove that emissive power of a black body in a hemispherical enclosure is π times the intensity of radiation. **(08 Marks)**
c. Calculate net heat radiated (exchange) per m^2 for two large parallel plates maintained at 800^0C and 300^0C. The emissivites of two plates are 0.3 and 0.6 respectively. **(04 Marks)**

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