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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.**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 ( $0.7\text{W/m}^{\circ}\text{C}$ ) and 3cm plaster ( $0.5\text{W/m}^{\circ}\text{C}$ ). An insulating material of  $K = 0.08\text{ W/m}^{\circ}\text{C}$  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  $\alpha$  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  $60^{\circ}\text{C}$  is to be insulated by a material having  $K = 0.174\text{W/m}^{\circ}\text{C}$ . Heat transfer coefficient  $h_a = 8\text{W/m}^2\text{K}$  and ambient temperature  $T_a = 25^{\circ}\text{C}$ . 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 ( $\rho = 2700\text{ kg/m}^3$ ,  $C_p = 0.896\text{ kJ/kg K}$  and  $K = 200\text{W/m}^{\circ}\text{C}$ ) and weighs 1.5 kg. The total area of iron is  $0.06\text{m}^2$  and it is heated with 500W heating element. Initially the iron is at  $25^{\circ}\text{C}$  (ambient Temp). How long it takes for the iron to reach  $110^{\circ}\text{C}$ . Take  $h_c = 15\text{W/m}^2\text{K}$ . (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 :  

$$\frac{T_{s,x} - T_c}{T_s - T_c} = \frac{3}{2} \frac{y}{\delta_t(x)} - \frac{1}{2} \left( \frac{y}{\delta_t(x)} \right)^2$$
, where  $\delta_{t,x} = 4.53 \frac{x}{\text{Re}_x^{1/2} \text{Pr}^{1/3}}$ . Develop an expression for local heat transfer coefficient  $h_{t,x}$ . (06 Marks)
  - c. A vertical pipe 15cm OD, 1m long has a surface temperature of  $90^{\circ}\text{C}$ . If the surrounding air is at  $30^{\circ}\text{C}$ . 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  $30^{\circ}\text{C}$ , 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  $90^{\circ}\text{C}$ . Use  

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

$$= [0.036 Re_L^{0.8} - 836] Pr^{0.33}$$
. (10 Marks)

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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 e.g. "2.18 = 50, will be treated as malpractice.

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- 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  $100^{\circ}\text{C}$  ( $C_p = 3.6\text{kJ/kg K}$ ) flows at a rate of  $30,000\text{ kg/hr}$  and enters a parallel flow heat exchanger. Cooling water ( $C_p = 4.2\text{kJ/kg K}$ ) enters heat exchanger at  $10^{\circ}\text{C}$  at the rate of  $50,000\text{ kg/hr}$ . The heat transfer area is  $10\text{m}^2$  and  $u = 1000\text{W/m}^2\text{K}$ . Calculate outlet temperature of oil and water. (10 Marks)
- 7 a. With neat sketch, explain the regions of pool boiling. (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  $5\text{cm}$  and length  $1.5\text{m}$ . If the surface is maintained at  $80^{\circ}\text{C}$ , 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  $\pi$  times the intensity of radiation. (08 Marks)  
c. Calculate net heat radiated (exchange) per  $\text{m}^2$  for two large parallel plates maintained at  $800^{\circ}\text{C}$  and  $300^{\circ}\text{C}$ . The emissivities of two plates are  $0.3$  and  $0.6$  respectively. (04 Marks)

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