USN

10ME63

Sixth Semester B.E. Degree Examination, Dec.2015/Jan.2016

Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

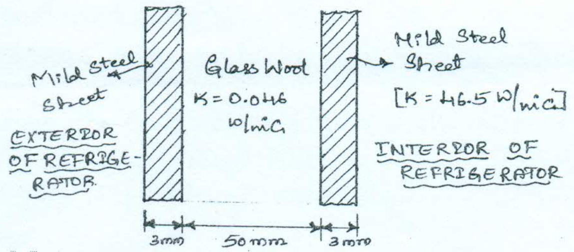
Note: 1. ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. ***Use of heat transfer data hand book and steam tables are permitted.***

PART - A

1 a. Derive the general 3 – D Heat conduction equation in Cartesian coordinate system and hence obtain Laplace and Poisson equations. **(10 Marks)**

b. The Interior of a Refrigerator having inside dimensions of 0.5 × 0.5m base area and 01 mtr height is to be maintained at 6^0C. The walls of the Refrigerator are constructed of 2 mild steel sheets, three (3mm) thick. [K = 46.5 W/m ^{0}C] with a 50mm of glass wool insulation [K = 0.046W/m ^{0}C] between them. If the Average Heat transfer coefficients at the inner and outer surfaces are 11.6W/m^2 ^{0}C and 14.5W/m^2 ^{0}C respectively.
Calculate : i) The rate at which the heat must be removed from the Interior to maintain the specified temperature in the kitchen at 25^0C and ii) The temperature on the outer surface of the metal sheet. **(10 Marks)**

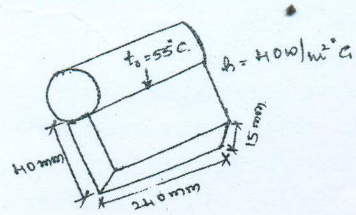
Fig.Q1(b)



2 a. Derive an expression for critical thickness of insulation for a sphere. **(08 Marks)**

b. A motor body is 360mm in diameter (OD) and 240mm long. It's surface temperature should not exceed 55^0C when dissipating 340 watts. Longitudinal fins of 15mm thickness and 40mm height are produced. The convection coefficient is 40W/m^2 ^{0}C. Determine the number of fins required. Assume, the atmospheric temperature is 30^0C for a finite fin. [Fig.Q2(a)]. **(12 Marks)**

Fig.Q2(b)



3 a. Show that the temperature distribution under Lumped analysis is given by,
$\frac{T - T_a}{T_i - T_a} = e^{-B_i F_o}$, where T_i = Initial temperature , T_a = Ambient temperature. **(10 Marks)**

b. A 15mm diameter Mild Steel Sphere (K = 42W/m ^{0}C) is exposed to cooling air flow at 20^0C resulting in the convective coefficient 'h' = 120 W/m^2 ^{0}C. Determine the following :
i) Time required to cool the sphere from 550^0C to 90^0C.
ii) Instantaneous heat transfer rate 2 minutes after start of cooling.
iii) Total energy transferred from the sphere during the first 2 minutes.
For Mild steel take : ρ = 7850 kg/m^3, C_p = 475 J/kg ^{0}C and α = 0.045 m^2/hr. **(10 Marks)**

4 a. Using Buckingham's π – theorem, obtain the relationship between various dimensionless numbers ($N_u = \phi (P_r)(G_r)$) for free convection heat transfer. **(08 Marks)**

b. Air at 20^0C and at a pressure of 1 bar is flowing over a flat plate at a velocity of 3m/sec if the plate is 280 mm wide and 56^0C. Calculate the following quantities at x = 280mm, given that the properties of air at bulk mean temperature = 38^0C are : ρ = 1.1374 kg/m^3, K = 0.02732 W/m ^{0}C , C_p = 1.005 kJ/kg ^{0}K, $\gamma = 16.768 \times 10^{-6}$ m^2/sec , P_r = 0.7.
i) Boundary layer thickness ii) Thickness of boundary layer iii) Local convective heat transfer coefficient iv) Average convective heat transfer coefficient v) Rate of heat transfer by convection vi) Total drag force on the plate. **(12 Marks)**

PART - B

5 a. Explain the significance of i) Reynold's number ii) Prandtl number iii) Nusselt number iv) Stanton number. **(10 Marks)**

b. A refrigerated truck is moving on a highway at 90km/hr in a desert area, where the ambient air temperature is 50^0C. The body of the truck is a rectangular box measuring 10mtr (length) × 4m(width) × 3m(height). Assume that the boundary layer on the four walls is turbulent. The heat transfer takes place only from the four surfaces and the wall surfaces of the truck is maintained at 10^0C. Neglecting heat transfer from front and back and assuming flow to be parallel to 10m long side, calculate : i) A heat lost from the four surfaces ii) The power required to overcome the resistance acting on the four surfaces. The properties of air (at $t_f = 30^0$C) are: ρ = 1.165kg/m^3 , C_p = 1.005 kJ/kg ^{0}C , K = 0.02673W/m ^{0}C , $\gamma = 16 \times 10^{-6}$ m^2/S , P_r = 0.701. **(10 Marks)**

6 a. Derive an expression for LMTD of counter flow heat exchanger. State the assumptions made. **(10 Marks)**

b. 8000 kg/hr of air at 100^0C is cooled by passing it through a single pass cross flow heat exchanger. To what temperature is the air cooled, if water entering a 15^0C flows through the tubes unmixed at the rate of 7500 kg/hr. Take , U = 500kJ/hr – m^2 ^{0}C , A = 20m^2 , C_p of air = 1kJ/kg ^{0}C , C_p of water = 4.2 kJ/kg ^{0}C. [Fig.Q6(a)] **(10 Marks)**

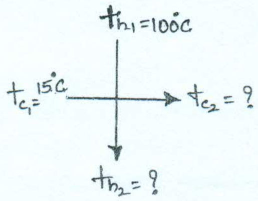


Fig.Q6(a)

7 a. Define i) Pool boiling ii) Forced convection boiling iii) Sub cooled iv) Local boiling iv) Saturated boiling. **(08 Marks)**

b. Explain Fick's law of diffusion. **(04 Marks)**

c. A vertical tube (Taking Experimental value) of 60mm OD and 1.2mtr long is exposed to steam at atmospheric pressure. The outer surface of the tube is maintained at a temperature of 50^0C by circulating cold water through the tubes. Calculate i) Rate of heat transfer to the coolant ii) The rate of condensation of steam. Assuming the condensation film is Laminor and TPP of water at 75^0C are: ρ_L = 975 kg/m^3, $\mu_L = 375 \times 10^{-6}$ N-S/m^2 , K = 0.67W/m^0 C. The properties of saturated vapor t_{sat} = 100^0C , ρ_v = 0.596 kg/m^3, h_{fg} = 2257kJ/kg. **(08 Marks)**

8 a. For a Black body enclosed in a hemispherical space, show that emissive power of Black body is π times the Intensity of Radiation. **(08 Marks)**

b. State and explain i) Kirchoff's law ii) Planck's law iii) Wein's displacement law iv) Lambert's cosine law. **(08 Marks)**

c. Explain briefly the concept of a Blackbody. **(04 Marks)**

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