2002 SCHEME

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ME74

Seventh Semester B.E. Degree Examination, June 2012

Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. *Answer any FIVE full questions.*
2. *Use of Heat & Mass Transfer data handbook is permitted.*

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.

1 a. Explain the following : i) Concept of driving potential ii) Initial and boundary conditions as applied to heat transfer problems. **(06 Marks)**

b. Sheets of brass and steel, each of thickness 1cm, are placed in contact. The outer surface of steel is kept at 0^0C. The outer surface of brass plate is at 100^0C. What is the temperature of the common interface? The thermal conductivities of brass and steel are in the ratio of 2 : 1. **(06 Marks)**

c. A hollow cylinder with inner radius 30mm and outer radius 50mm is heated at the inner surface at a rate of 10^5W/m^2 and dissipates heat by convection from the outer surface into a fluid at temperature 100^0C with a heat transfer coefficient of 400 W/m^2 K. The thermal conductivity of the solid is 15W/mK. Calculate the temperatures of the inside and outside surfaces of the cylinder. **(08 Marks)**

2 a. Twelve fins made of material of K = 75W/m K having 0.75mm thickness protrude 25mm from a cylindrical surface of 50mm diameter and 1m length placed in an atmosphere of 40^0C. If the cylindrical surface is maintained at 150^0C and the heat transfer coefficient is 23W/m^2 K, calculate i) the rate of heat transfer ii) the percentage increase in heat transfer due to fins iii) the temperature at the centre of fins and iv) the fin efficiency and effectiveness. Assume no heat transfer from fin tips due to negligible area. **(12 Marks)**

b. A wire of 6.5mm diameter at a temperature of 60^0C is to be insulated by a material having K = 0.174W/mK. The ambient temperature is 20^0C. The convective heat transfer coefficient is 8.72W/m^2 K. For maximum heat loss, find the thickness of insulation and the heat loss per unit length. What is the percentage increase in heat dissipation due to insulation? **(08 Marks)**

3 a. A load of peas at a temperature of 25^0C is to be cooled down in a room at an air of temperature of 1^0C i) How long the peas will require to cool down to 2^0C when the surface heat transfer coefficient of the peas is 5.81W/m^2 K? ii) What is the temperature of the peas after a lapse of 10 minutes from the start of cooling? iii) What air temperature must be used if the peas were to be cooled down to 5^0C in 30 minutes? The peas are supposed to have an average diameter of 8mm. The density of peas is 750 kg/m^3 and specific heat 3.35 kJ/kg K. **(09 Marks)**

b. What is time constant of a thermocouple? Show that, for a thermocouple,

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-1} = 0.368.$$ **(05 Marks)**

c. Define and explain the physical significance of i) Biot number ii) Fourier number. **(06 Marks)**

4 a. Air at 10^0C and at a pressure of 100 kPa is flowing over a plate at a velocity of 3m/s. If the plate is 30cm wide and at a temperature of 60^0C, calculate the following quantities at x = 0.3m. i) Velocity boundary layer thickness ii) Thermal boundary layer thickness iii) Local friction coefficient iv) Local shearing stress v) Total drag force vi) Local convection heat transfer coefficient vii) Heat transfer from the plate. The relevant properties of air are : Density = 1.13 kg/m^3 ; Dynamic viscosity = 19×10^{-6} kg/mS ; Prandtl no = 0.7 ; Thermal conductivity = 0.027W/m K ; Specific heat = 1.006 kJ/kg K. **(14 Marks)**

b. Briefly explain the following : i) Critical Reynolds number ii) Fully developed flow iii) Constant wall temperature and constant heat flux conditions. **(06 Marks)**

5 a. Calculate the average heat transfer coefficient and friction factor for flow of n – butyl alcohol at a mean temperature of 20^0C through a 0.1×0.1m square duct, 5m long with walls at 27^0C, if the average velocity is 0.03m/s. The relevant physical properties of n – butyl alcohol are : ρ = 810 kg/m^3 ; K = 0.167W/m K ; Cp = 2366 J/kg K ; $\nu = 3.64 \times 10^{-6} m^2/s$; P_r = 50.8. Assume fully developed flow. **(10 Marks)**

b. Estimate the heat transfer rate from a 100 Watt incandescent bulb at 140^0C to an ambient at 24^0C. Approximate the bulb as 60cm diameter sphere. Calculate the percentage of power lost by natural convection. Use the correlation Nu = 0.60 $(Gr.Pr)^{1/4}$. Properties of air at relevant temperature are : $\nu = 21.46 \times 10^{-6} m^2/s$, K = 30.38×10^{-3} W/m K , P_r = 0.699. **(10 Marks)**

6 a. Derive an expression for the determination of LMTD of a parallel flow heat exchanger. **(08 Marks)**

b. Determine the overall heat transfer coefficient Uo based on the outer surface of a 2.54cm OD, 2.286 cm ID heat exchanger tube (K = 102W/m K), if the heat transfer coefficients at the inside and outside of the tube are hi = 5500W/m^2 K and ho = 3800 W/m^2 K respectively and the fouling factors are $R_{fo} = R_{fi}$ = 0.0002 m^2/W K. **(04 Marks)**

c. Dry steam at 100^0C condenses on the outside of a horizontal pipe of 2.5cm OD. The pipe surface is maintained at 84^0C by circulating water through it. Determine the rate of formation of condensate per meter length of the pipe. **(08 Marks)**

7 a. State the Stefan – Boltzmann's law of heat radiation. **(03 Marks)**

b. Distinguish between i) a black body and a gray body ii) Specular and diffuse surfaces iii) Absorptivity and emissivity of a surface iv) Total emissivity and equilibrium emissivity. **(08 Marks)**

c. Assuming the sun to be a black body having a surface temperature of 5800K, calculate i) the total emissive power ii) the wavelength at which the maximum spectral intensity occurs iii) the maximum value of $E_{b\lambda}$ iv) the percentage of total emitted energy that lies in the visible range of 0.35μ to 0.76μ and v) the total amount of radiant energy by the sun per unit time if the diameter is 1.391×10^9m. **(09 Marks)**

8 a. Give a comparison of Newton's law of viscosity ; Fourier's law of heat conduction ; and Fick's law of diffusion. **(06 Marks)**

b. Define the following : i) Mass diffusion coefficient ii) Mass transfer coefficient. **(04 Marks)**

c. Calculate the rate of diffusion of water vapour from a pool of water at the bottom of a well 6 metre in depth to dry air flowing over the top of the well. Assume the entire system at 25^0C and 1 atm. Take D = 0.256cm^2/S. **(10 Marks)**

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