Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – V (NEW) EXAMINATION – WINTER 2015

Subject Code: 2151909 **Date:17/12/ 2015**

Subject Name: Heat Transfer

Time:10:30am to 1:00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Derive an expression for three dimensional time dependent heat conduction with internal heat generation and constant thermal conductivity in cartesian coordinate system. Reduce it as **07**

i. Poisson equation
ii. Fourier equation
iii. Laplace equation

(b) A steam pipe of 5 cm inside diameter and 6.5 cm outside diameter is insulated with a 2.75 cm radial thickness of high temperature insulation (k = 1.1 W/mK). The surface heat transfer coefficient for inside and outside surfaces are 4650 W/m^{2}K and 11.5 W/m^{2}K respectively. The thermal conductivity of the pipe material is 45 W/mK. If the steam temperature is 200°C and ambient air temperature 25°C, determine **07**

i. Heat loss per meter length of pipe
ii. Temperature at the interface
iii. Overall heat transfer coefficient

Q.2 **(a)** If a thin and long fin, insulated at its tip is used, show that the temperature distribution along the fin is given by **07**

$$\frac{\theta_x}{\theta_0} = \frac{T_x - T_\infty}{T_0 - T_\infty} = \frac{\cosh\{m(L-x)\}}{\cosh mL}$$

(b) A steel fin (k = 54 W/mK) with a cross section of an equilateral triangle, 5 mm in side and 80 mm long. It is attached to a plane wall maintained at 400°C. The ambient air temperature is 50°C and convective heat transfer coefficient at surface is 90 W/m^{2}K. Calculate the heat dissipation rate from the rod. **07**

OR

(b) An aluminum sphere weighing 6 kg and initially at temperature of 350°C is suddenly immersed in a fluid at 30°C with convective coefficient of 60 W/m^{2}K. Estimate the time required to cool the sphere to 100°C. Take thermo physical properties of sphere as **07**

C = 900 J/kgK, ρ = 2700 kg/m^3 k = 205 W/mK

Q.3 **(a)** For forced convection heat transfer, prove that $Nu_D = f(\mathrm{Re}_D, \mathrm{Pr})$ using dimensional analysis. Where Nu = Nusselt number, Re_D = Reynold number and Pr = Prandtl number. **07**

(b) Water at 50°Centers 1.5 cm diameter and 3 m long tube with a velocity of 1.5 m/s. The tube wall is maintained at 100°C. Calculate the heat transfer coefficient and total amount of heat transferred if the water exit temperature is 70°C. **07**

The relevant properties of water are Pr = 3.15, $\rho = 990$ kg/m^3

$\nu = 0.517 \times 10^{-6}$ m^2/s, $C_p = 4184$ J/kgK, $k_f = 0.65$ W/mK

Use following correlation

$$Nu_D = 0.023\left(\mathrm{Re}_D\right)^{0.8}\left(\mathrm{Pr}\right)^{0.4}$$

OR

Q.3 **(a)** Explain the Reynold Colburn analogy for laminar flow over a flat plate. **07**

(b) A horizontal 40 W fluorescent tube which is 3.8 cm in diameter and 120 cm long stands in still air at 1 atm and 20°C. If the surface temperature is 40°C and radiation is neglected, what percentage of power is being dissipated by convection? **07**

Use following properties of air

$\nu = 16.19 \times 10^{-6}$ m^2/s, Pr = 0.706, $k_f = 0.02652$ W/mK

Use following correlation

$$Nu_D = 0.53\left(Ra_D\right)^{1/4}$$

Q.4 **(a)** Derive an expression for log mean temperature difference of parallel flow heat exchanger. **07**

(b) Hot water at 2.5 kg/s and 100°C enters a concentric tube counter flow heat exchanger having a total area of 23m^2. Cold water at 20°C enters at 5 kg/s and the overall heat transfer coefficient is 1000 W/m^{2}K. Determine the total heat transfer rate and the outlet temperature of hot and cold fluids. **07**

OR

Q.4 **(a)** Discuss the various regimes in boiling and explain (i) the condition for the growth of bubbles and (ii) effect of bubble size on boiling **07**

(b) The outer surface of a vertical tube 80 mm in outer diameter and 1 m long is exposed to saturated steam at atmospheric pressure. The tube surface is maintained at 50°C by flow of water through the tube. What is the rate of heat transfer to coolant and what is the rate of condensation of steam? **07**

Use following properties of saturated vapor and water, $\mu = 375 \times 10^{-6}$ kg/ms

$h_{fg} = 2257$ kJ/kg, $\rho = 975$ kg/m^3, $\rho_v = 0.596$ kg/m^3, $k_f = 0.668$ W/mK

Q.5 **(a)** Define total emissive power (E_b) and intensity of radiation (I_b). Show that $E_b = \pi \times I_b$ **07**

(b) A gray, diffuse opaque surface (Absorptivity $\alpha = 0.8$) is at 100ºC and receives an irradiation 1000 W/m^2. If the surface area is 0.1 m^2, calculate **07**

i. Radiosity of the surface
ii. Net radiative heat transfer rate from the surface
iii. Calculate above quantities if surface is black.

OR

Q.5 **(a)**

1. What are the radiation surface and space resistances? How are they expressed? For what kind of surface, is radiation surface resistance zero? **03**
2. What does the view factor represents? When the view factor from a surface to itself not zero? **02**
3. What is radiation shield? Where is it used? **02**

(b) A cubical room 4 m × 4 m × 4 m is heated through the ceiling by maintaining it at uniform temperature of 350 K, while walls and the floor are at 300 K. Assuming that the all surfaces have an emissivity of 0.8, determine the rate of heat loss from ceiling by radiation. **07**

****