Ex/BESUS/ ME- 604/ 06

B.E. (ME) Part-III 6th Semester Examination, 2006

Heat Transfer

(ME-604)

Time : 3 hours   Full Marks : 100

Use separate answerscript for each half.

The questions are of equal value.

FIRST HALF

(Answer Q.No.l and Q.No.2 and also answer either Q.No.3 or Q.No.4.)

1. a) Consider free convection heating of a fluid passing over a vertical flat plate. Using dimensional analysis prove that

   $Nu = C.Gr^m Pr^n$ where C, m

   and n are constants.

b) A glass-door firescreen, used to reduce exfiltration of room air through a chimney, has a height of 0.71 m and a width of 1.02 m and reaches a temperature of 232°C. If the room temperature is 23°C, estimate the convection heat rate from the fireplace to the room.

At T_f= 127.5°C, for air k = 33.8 x 10~^{3} W/mK

v = 26.4x 10~^{6}m^2/s a =

38.3x 10"^{6}m^2/s

P_r = 0.690 , p = 4- = 0.0025/K ^{r}**f**

Use the correlation :

0.387 Ra,$^{/6}$

(

Nu_L = < 0.825 +

Assuming e = 1.0, also calculate the radiation heat transfer between the glass and the surroundings. Given *a* = 5.67 x 10~^{8} W/m^{2}K^4.

2. a) Calculate the heat transfer coefficient during laminar film condensation of a pure, stationary and saturated vapour at a temperature T_s on an isothermal vertical plate at a temperature T_w. State the assumptions.

b) The outer surface of a vertical tube, which is 1 m long and has an outer diameter of 80 mm, is exposed to saturated steam at atmospheric pressure and is maintained at 50°C by the flow of cool water through the tube. What is the rate of heat transfer to the coolant, and what is the rate at which steam is condensed at the surface?

Given : T_{sat} = 100°C , P_v = (-U = 0.596 kg/m^3 V

2257 kJ/kg

At T_f = 75°C : P_l = -i- = 975 kg/m^3

u_7 = 375x10~^{6}N.s/m^2 k,

= 0.668 W/mK $C_{pj/}$ =

4193J/kg.K

Jakob no., Ja = ^{C}p,/(^{T}sat-^{T}s) / h_{fg} l fo ^{h}fg~^{h}fg / 0.68 h_{fg} U.UO I

Use h_L = 0.943 —l—L.—v—l—s—L / ^/(^{T}sat-^{T}s)^{L} J

according to the Rohsenow recommendation.

3. a) State Planck's law of radiation. Form Planck's law derive Wien's displacement law.

b) What is shape factor? Calculate the shape factor, F_{12} between a small area Aj and a parallel plane circular disc A_2. Aj is located on the axis of the disc, and the semi-vertex angle of the cone formed with the disc as base and Aj as the vertex is a.

4. a) A stream of incompressible fluid at a temperature T^ moves parallel to and over a stationary flat plate with a steady free stream velocity V^. Assuming the flow to be laminar, calculate the heat transfer rate and the heat transfer coefficient if the plate is maintained at a constant temperature T_w. Justify the assumptions you make.

b) Show the three-zone enclosure radiation network. What would be the degenerated network if the third zone is a re-radiating surface.

SECOND HALF

[Answer any THREE Questions.)

5. a) Write down the mechanism of heat conduction in gases, liquids and solids.

   b) Define thermal conductivity. How can it be determined experimentally? Explain the difference between thermal conductivity and thermal conductance.

   c) Water flows at 50°C inside a 2.5 cm inner diameter tube such that hj = 3500 W/m^2K. The tube has a wall thickness of 0.8 mm with a thermal conductivity of 16W/mK. The outside of the tube loses heat by free convection with h_0 = 7.6 W/m^2K. Calculate the overall heat transfer coefficient and heat loss per unit length to the surrounding air at 20°C.

6. a) Show that the temperature profile for heat conduction through a wall of constant thermal conductivity is a straight line and in presence of a heat source it becomes parabolic.

   b) An electric current of 34000 ampere flows along a flat steel plate 12.5 mm thick and 100 mm wide. The temperature of one surface of the plate is 82°C and that of the other is 95°C. Find the temperature distribution across the plate, and the value and the position of the maximum temperature. Also calculate the total amount of heat generated per metre length of the plate and the flow of heat from each surface of the plate. The end effects along the short sides of the plate may be neglected.
   Given for steel p = 12 x $10^{\sim 6}$ Qcm and k = 52.4 W/mK

7. a) Explain the concept of critical radius of insulation. Explain why an insulated small diameter wire has a higher current carrying capacity than an unisulated one.

   b) A copper rod of diameter 5 mm is heated by the flow of current. The surface of the rod is maintained at 175°C while it is dissipating heat by convection (h = 150 W/m^2K) into the ambient air at 25°C. If the rod is covered with a 1 mm thick coating (k = 0.6 W/mK), will the heat loss from the rod increase or decrease?

8. a) What are the norms for the measurement of the performance of fins?

   b) Determine the efficiency of a rectangular fin of length / and thickness *b*.

c) Determine the heat transfer rate from the rectangular fin of length 20 cm. width 40 cm and thickness 2 cm. The tip of the fin is not insulated and the fin has a thermal conductivity of 150 W/mK. The base temperature is 100°C and the fluid is at 20°C. The heat transfer coefficient between the fin and the fluidis30W/m^2K.

9. a) What is lumped system analysis? When is it applicable?

b) An average human body modelled as a 30 cm diameter 170 cm long cylinder has 72% water by mass, so that its properties may be taken as those of water at room temperature : density p = 1000 kg/m^3, c = 4180 J/kgK and k = 0.608 W/mK. A person is found dead at 5 A.M. in a room, the temperature of which is 20°C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient is estimated to be 8 W/mK. Assuming the body temperature of a living man to be 37°C, estimate the time of death of the above person.

c) A 25 cm thick wall of common brick is initially at 80°C, and suddenly its surfaces are reduced to 15°C. Find the temperature at a point 10 cm from the surface after 2 hours.

Assume : p = 1.6 x 10^3 kg/m^3, c = 0.84 kJ/kgK, a = 5.2 x 10^{-7} m^2/s, k = 0.7 W/mK.