



ANNA UNIVERSITY, CHENNAI
DEPARTMENT OF MECHANICAL ENGINEERING
VI SEMESTER B.E. – MECHANICAL ENGINEERING - APRIL / MAY 2012

TIME: 3 HRS

ME 9355 HEAT AND MASS TRANSFER

MAX. MARKS: 100

3

INSTRUCTIONS

1. ANSWER ALL QUESTIONS
2. USE OF APPROVED DATA BOOK IS PERMITTED
3. ASSUME MISSING DATA SUITABLY

PART - A

(10 x 2 = 20)

1. Distinguish Radiation energy transfer from that of conduction and Convection.
2. Typical 'h' values in W/m^2K for free convection in liquids and gases respectively are:
(a) 50 - 100 and 2 - 25 (b) 2 - 25 and 50 - 100
(b) 25 - 250 and 50 - 100 (d) 50 - 100 and 25 - 250
3. Considering the critical radius of insulation explain whether the outer radius should be made greater than R critical or not for good electrical cables
4. A heated / cooled circular ring at T_i is suddenly exposed to fluid at T_∞ with a known h . When can the ring be assumed to be more or less isothermal to evaluate temperature at a given time or time to reach a particular temperature.
5. Draw the thermal and velocity boundary layers for heavy oils and liquid metals flowing over a flat plate.
6. Define the reciprocity rule applicable to shape factor between two bodies that exchange heat by radiation?
7. If $h_i = 250 W/m^2K$ and $h_o = 10 W/m^2K$ in a heat exchanger and if the overall heat transfer is to be enhanced by 10% practically, which heat transfer coefficient should be improved? Why?
8. What is the effect of non-condensable gases in steam condensers.
9. Distinguish between the velocity profile in a Vertical hot plate experiencing natural convection and forced convection with air flowing upward.
10. Distinguish between convective mass transfer and Diffusion mass transfer.

PART - B

(5 x 16 = 80)

(11) A simple counter-flow heat exchanger operates under the following conditions:

Fluid - A, inlet and outlet temperatures $80^\circ C$ and $40^\circ C$;

Fluid - B, inlet and outlet temperatures $20^\circ C$ and $40^\circ C$.

The exchanger is cleaned, causing an increase in the overall heat transfer coefficient by 10% and inlet temperature of fluid B is changed to $30^\circ C$. What will be new outlet temperatures of fluid A and of fluid B. Assume heat transfer coefficients and capacity rates are unaltered by temperature changes.

12(a) Aluminium square fins ($0.5 \text{ mm} \times 0.5 \text{ mm}$) of 10 mm length are provided on a surface of semiconductor electronic device to carry 1W of energy generated by electronic device. The temperature at the surface of the device should not exceed $80^\circ C$ when surrounding temperature is $40^\circ C$. Find the number of fins required to carry out the above duty. Neglect the heat loss from the end of fins. $k(\text{Al}) = 200 W/m^\circ C$; $h = 15 W/m^2^\circ C$

(OR)

12 (b) On a hot day the wood surface gets heated to 50°C to a considerable depth. Sudden sharp showers cool the surface to 20°C and maintain the surface at this temperature level. Determine the temperature at 2 cm depth after 40 minutes. The material properties are : density = 2115 kg/m^3 . Specific heat = 920 J/kg K . Conductivity = 0.062 W/mK . Also calculate the heat flow from the surface up to the time, instantaneous heat flow at the surface and at 0.02m depth.

13(a) A 6m long section of an 8-cm-diameter horizontal hot water pipe passes through a large room whose temperature is 20°C . If the pipe outer surface temperature is 70°C , determine the rate of heat loss from the pipe by natural convection. Check for what value of emissivity the radiation loss will be less than convective loss.

(OR)

13(b) A 25 -cm- diameter stainless steel ball ($\rho = 8055 \text{ kg/m}^3$, $C_p = 480 \text{ J/kg.}^{\circ}\text{C}$) is removed from the oven at a uniform temperature of 300°C . The ball is then subjected to the flow of air at 1 atm pressure and 25°C with a velocity of 3 m/s. The surface temperature of the ball eventually drops to 200°C . Determine the average convection heat transfer coefficient during this cooling process and estimate how long the process will take.

14 (a) The radiation shape factor of the circular surface of a thin hollow cylinder of 10 cm diameter and 10 cm length is 0.1716. What is the shape factor of the curved surface of the cylinder with respect to itself?

(OR)

14 (b) The net radiation from the surfaces of two parallel plates maintained at T_1 and T_2 is to be reduced by 99%. Calculate the number of screens to be placed between the two surfaces to achieve this reduction in heat exchange assuming the emissivity of the screens as 0.05 and that of surfaces as 0.8.

15 (a)(i) A cross flow heat exchanger with both fluids unmixed is used to heat water flowing at a rate of 20 kg/s from 25°C to 75°C using gases available at 300°C to be cooled to 180°C . The overall heat transfer coefficient has a value of $95 \text{ W/m}^2\text{K}$. Determine the area required. For gas $C_p = 1005 \text{ J/kgK}$ (8)

(ii) With a neat sketch explain the Flow boiling heat transfer regimes along with the variation in heat transfer coefficient. (8)

(OR)

15(b) Air at 25°C and 50% RH flows over water surface measuring $12\text{m} \times 6\text{m}$ at a velocity of 2 m/s. Determine the water loss per day considering flow direction along the 12m side. Compare the loss if the air flow is along the 6m side .