USN | | | | | | | | | | | **12MTP21/13MTH21**

Second Semester M.Tech. Degree Examination, June/July 2014
Advanced Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note: ***1. Answer any FIVE full questions.***
2. Use of heat transfer and thermodynamics data hand book is permitted.

1 a. Briefly discuss on different modes of heat transfer and state the fundamental laws governing them. **(06 Marks)**

b. Starting from fundamentals derive the differential equation for temperature distribution in a fin. **(08 Marks)**

c. In conductivity measuring experiment two identical long rods are used. One rod is made of aluminium (k = 200 W/mk), while the other rod is a specimen. One end of both rods are fixed to a wall at 100°C, while the other end is suspended in air at 25°C. The steady temperature at same distance along the rods were measured and found to be 75°C on a aluminium rod and 60°C on specimen rod. Find thermal conductivity K for specimen assuming insulated tip. **(06 Marks)**

2 a. Define conduction shape factor and explain its significance. **(06 Marks)**

b. Two parallel 50cm diameter disks are separated by a distance of 1.5m in an infinite medium having K = 2.3 W/m°C. One disk is maintained at 80°C and the other at 20°C. Calculate the conduction shape factor and the heat transfer between the disks. **(08 Marks)**

c. Explain the method of solving a 2-d heat conduction problem using electrical analogy. **(06 Marks)**

3 a. State the following laws as applied to thermal radiation:

i) Kirchoff's law
ii) Stefan-Boltzmann law
iii) Wien's displacement law
iv) Lambert's cosine law. **(08 Marks)**

b. Two very large planes with emissivities 0.3 and 0.8 exchange heat. Find the percentage reduction in heat transfer when a polished-aluminum radiation shield ($\in$ = 0.04) is placed between them. **(12 Marks)**

4 a. Derive the momentum equation for the laminar boundary layer on a flat plate. State the assumptions made. **(10 Marks)**

b. Air at 20°C and atmospheric pressure is flowing over a flat plate at a velocity of 3 m/s. If the plate is 30cm wide and at a temperature of 60°C. Calculate the following quantities at x = 0.3m:

i) Thickness of velocity and thermal boundary layer.
ii) Local and average friction coefficient.
iii) Local and average heat transfer coefficient.
iv) Total drag force on the plate.

At 313K take the following properties of air $\rho = 1.18 kg/m^3$; $\gamma = 17 \times 10^{-6} m^2/s$; k = 0.0272 W/m°C. C_p = 1.007 kJ/kg°C, P_r = 0.705. **(10 Marks)**

5 a. Derive an expression for forced convection heat transfer in terms of dimensionless parameters using dimensional analysis. **(10 Marks)**

b. Air at 2 atm and 200°C is heated as it flows through a tube with a diameter of 25.4mm at a velocity of 10m/s. Calculate the heat transfer per unit length of the tube if a constant heat flux condition is maintained at the wall and the tube wall temperature is 20°C above the air temperature, all along the tube length. How much would the bulk temperature increase over a 3m length of the tube? Take properties of air at a bulk temperature of 200°C as,
ρ = 1.493 kg/m^3; P_r = 0.681; $\mu = 2.57 \times 10^{-5}$ kg/m-s; k = 0.0386 W/m°C; C_p = 1.025 kJ/kg°C. **(10 Marks)**

6 a. Define and explain the significance of
i) Reynolds number
ii) Prandtl number
iii) Grashof number
iv) Nusselt number. **(08 Marks)**

b. A hot square plate 50cm × 50cm at 100°C is exposed to atmospheric air at 20°C. Find the heat loss from both surfaces of the plate if i) Plate is kept vertical; ii) Plate is kept horizontal. Use the following relation:
$Nu = 0.13\,(GrPr)^{1/3}$ for vertical position.
$Nu = 0.71\,(GrPr)^{1/4}$ for upper surface.
$Nu = 0.35\,(GrPr)^{1/4}$ for lower surface. **(12 Marks)**

7 a. Derive an expression for effectiveness of a counter flow heat exchanger in terms of number of transfer units (N) and heat capacity ratio of two fluids (C). **(10 Marks)**

b. Find out the length of tube required for the following heat transfer in a parallel flow heat exchanger where air is heated by exhaust gases Q = 9.3 kW, d_i = 5cm, d_o = 6cm, h_i = 116 W/m^2°C, h_o = 186 W/m^2°C. Inlet and outlet temperatures of hot fluid are respectively 400°C and 150°C, and for cold fluid are respectively 50°C and 100°C. Neglect tube resistance. If the flow is made counter flow, what is the percentage of saving in tube length? **(10 Marks)**

8 a. Explain the different regimes of pool boiling using an appropriate boiling curve. Indicate CHF and Leiden Frost points on it. **(10 Marks)**

b. Air free saturated steam at 85°C and pressure of 57.8 kPa condenses on the outer surface of 225 horizontal tubes of 1.27 cm OD arranged in a square array. The surface is maintained at a uniform temperature of 75°C. Calculate the total condensation rate per meter length of the tube bundle. **(10 Marks)**

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