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06ME65

Sixth Semester B.E. Degree Examination, June 2012
Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer FIVE full questions, selecting at least TWO questions from each part.***
2.Use of heat transfer data handbook is permitted.

PART – A

1 a. What do you mean by boundary condition of 1st, 2nd and 3rd kind? **(06 Marks)**

b. Derive general heat conduction equation in cartesion co-ordinates. **(08 Marks)**

c. A 0.8 m high and 1.5 m wide double plane window consists of two 4 mm thick layers of glass (k = 78 W/m°C), separated by a 10 mm wide stagnant air space (k = 0.026 W/m°C). Determine the rate of heat transfer through this window and the temperature of the inside surface, when the room is maintained at 20 °C and the outside air is at –10 °C. Take the convention heat transfer co-efficients on the inside and outside surfaces of the window as 10 and 40 W/m°C respectively. **(06 Marks)**

2 a. What is physical significance of critical thickness of insulation? Derive an expression for critical thickness of insulation for a cylinder. **(06 Marks)**

b. Derive an expression for temperature distribution for a pin fin with the tip insulated. **(08 Marks)**

c. A carbon steel (k = 54 W/ m°C) rod with a cross section of an equilateral triangle (each side 5 mm) is 80 mm long. It is attached to a plane wall which is maintained at a temperature of 400 °C. The surrounding environment is at a 50 °C and unit surface conductance is 90 W/ m°C. Compute the heat dissipated by the rod (assuming tip is insulated). **(06 Marks)**

3 a. What are Biot and Fourier numbers? Explain their physical significance. **(06 Marks)**

b. Obtain an expression for instantaneous heat transfer and total heat transfer for lumped heat analysis treatment heat conduction problems. **(08 Marks)**

c. A solid copper sphere of 10 cms dia [density 8954 kg/m^3, specific heat 383 J/kg °C, thermal conductivity 386 W/ °C] initially at a uniform temp t_i = 250 °C is suddenly immersed in a well stirred fluid which is maintained at a uniform temperature t_a = 50°C, the heat transfer co-efficient between the sphere and the fluid is 200 W/$m^{2°}$C. Determine the temperature of the copper block at 5 minutes after the immersion. **(06 Marks)**

4 a. With reference to fluid flow over a flat plate, discuss the concepts of velocity boundary layer and thermal boundary layer, with necessary sketches. **(06 Marks)**

b. Air at 27 °C and at atmospheric pressure flows over a flat plate at a speed of 2 m/sec. If the plate is maintained at 93 °C, calculate the heat transfer per unit width of the plate, assuming the length of the plate along the flow of air is 2 metres. **(08 Marks)**

c. A steam pipe 5 cms diameter is lagged with insulating material of 2.5 cm thick. The surface temperature is 80 °C and emissivity of the insulating material surface is 0.93. Find the total heat loss from 10 metre length of pipe considering the heat loss by natural convection and radiation. The temperature of the air surrounding the pipe is 20 °C. Also find the overall heat transfer co-efficient and heat transfer co-efficient of radiation. **(06 Marks)**

PART – B

5 a. With the help of dimensional analysis, derive expression for the Reynolds number, Prandtl number and Nusselt number. **(10 Marks)**

b. A surface condenser consists of two hundred thin walled circular tubes (each tube is 22.5 mm diameter and 5 m long) arranged in parallel, through which water flows. If the mass flow rate of water through the tube bank is 160 kg/sec and its inlet and outlet temp are known to be 21°C and 29°C respectively, calculate the average heat transfer co-efficient associated with flow of water. **(10 Marks)**

6 a. Derive an expression for LMTD for a counter flow heat exchanger. **(10 Marks)**

b. The velocity of water flowing through a tube of 2.2 cms diameter is 2 m/sec. Steam condensing at 150 $^{\circ}$C on the outside surface of the tube heats the water from 15 $^{\circ}$C to 60 $^{\circ}$C over the length of the tube. Find the heat transfer co-efficient and the length of the tube neglecting the tube and steam side film resistance. **(10 Marks)**

7 a. Clearly explain the regions of pool boiling with neat sketch. **(06 Marks)**

b. State Fick′s law of diffusion. What are its limitations? **(06 Marks)**

c. A vertical square plate (30 cms × 30 cms) is exposed to steam at atmospheric pressure. The plate temp is maintained at 98°C. Calculate the heat transfer rate and mass of steam condensed per hour. Take the properties of water film at mean temperature.
Density = 960 kg/m^3
Dynamics viscosity = 282×10^{-6} kg/m.s
Thermal conductivity = 0.61 W/m$^{\circ}$C
Latent heat = 2255 kJ/kg
Temp of the steam = 100 $^{\circ}$C. **(08 Marks)**

8 a. Define the following:
i) Black body
ii) Kirchoff′s law
iii) Stefan boltzman law.
iv) Wein′s displacement law.
v) Plank′ law. **(10 Marks)**

b. Two large parallel planes having emissivities at 0.3 and 0.5 are maintained at temperature of 800 $^{\circ}$C and 300 $^{\circ}$C respectively. A radiation shield having an emissivity of 0.05 on both sides is placed between the two planes.
Calculate:
i) Heat transfer per unit area without shield.
ii) Find the temperature of the shield and heat transfer per unit area with shield. **(10 Marks)**

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