USN | | | | | | | | | | | 15AU62

Sixth Semester B.E. Degree Examination, Aug./Sept. 2020
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: ***1. Answer any FIVE full questions, choosing ONE full question from each module.***
2. Use of heat transfer data hand book is permitted.

Module-1

1 a. Explain the modes of heat transfer. **(03 Marks)**
b. State the laws governing three basic modes of heat transfer. **(05 Marks)**
c. Derive general 3 – dimensional heat conduction equation in Cartesian co-ordinates. **(08 Marks)**

OR

2 a. Derive an expression for the temperature distribution and the rate of heat transfer for a hollow cylinder. **(08 Marks)**
b. A wall is constructed of several layers. The first layer consists of brick (k = 0.66 w/m k), 25cm thick, the second layer 2.5cm thick mortar (k = 0.7 w/m k), the third layer 10cm thick limestone (k = 0.66 w/m k) and outer layer of 1.25cm thick plaster (k = 0.7 w/m k). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 w/m^2k and 11.6 w/m^2k respectively.
Find :
i) Overall heat transfer coefficient
ii) Overall thermal resistance per m^2
iii) Rate of heat transfer per m^2, if the interior of the room is at 26°C while outer air is at – 7°C
iv) Temperature at the junction between mortrar and limestone. **(08 Marks)**

Module-2

3 a. Obtain an expression for temperature distribution and heat flow through a rectangular fin, when the end of fin is insulated. **(08 Marks)**
b. An electronic semiconductor device has a rating of 60mw. In order to keep its proper operation, the inside temperature should not exceed 70°C. The device can dissipate about 20mw of heat on its own when placed in an environment at 40°C with heat transfer coefficient of 12.5 W/m^2 k. To avoid overheating of the device, it is proposed to install aluminium (k = 190 W/m k) square fins 0.6mm side, 10mm long, to provide additional cooling. Find the number of fins required. Assume no heat loss from the tip of fins. **(08 Marks)**

OR

4 a. Explain the following with their significance
i) Biot number
ii) Fourier number
iii) Thermal time constant. (06 Marks)

b. In a quenching process, a copper plate 3mm thick is heated upto 400°C and then exposed to an ambient at 25°C, with the convection coefficient of $28 w/m^2k$. Calculate the time required for the plate to reach the temperature of 50°C. Take thermo-physical properties as C = 380 J/kg k, P = 8800 kg/m^3, k = 385 W/m-k. (06 Marks)

c. An aluminium cylinder (k = 210 W/m k) 50mm in diameter and 10cm long is initially at uniform temperature of 200°C. Take h = 530 W/m^2k. What is the temperature on centerline of the cylinder after one minute? (04 Marks)

Module-3

5 a. Explain the following :
i) Velocity boundary layer
ii) Thermal boundary layer. (04 Marks)

b. Vertical door of a hot oven is 0.5m high and is maintained at 200°C. It is exposed to atmospheric air at 20°C. Find :
i) Local heat transfer coefficient half way up the door
ii) Average heat transfer coefficient for entire door
iii) Thickness of free convection boundary layer at the top of the door. (12 Marks)

OR

6 a. A rectangular tube, 30mm × 50mm carries water at a rate of 2kg/s. Determine the length of tube required to heat water from 30°C to 50°C, if the wall temperature is maintained at 90°C. (08 Marks)

b. In a long annulus (3.5cm ID and 5cm OD), the water is heated by maintaining the outer surface of inner tube at 60°C. The water enters at 20°C and leaves at 34°C. While its flow rate is 2 m/s. Estimate the heat transfer coefficient. (08 Marks)

Module-4

7 a. Derive an expression for LMTD of parallel flow heat exchanger. (08 Marks)

b. A heat exchanger is required to cool 55,000 kg/h of alcohol from 66°C to 40°C using 40,000 kg/h of water entering at 5°C.
Calculate :
i) Exit temperature of water
ii) Heat transfer rate
iii) Surface area required for
  i) Parallel flow type
  ii) Counter flow type of heat exchanger

Take overall heat transfer coefficient U = 580 w/m^2 k

$C_{P(alcohol)}$ = 3760 J/kg k

$C_{P(water)}$ = 4180 J/kg k. (08 Marks)

OR

8 a. With neat sketch, explain the regions of pool boiling. **(08 Marks)**

b. A steam condenser consists of a square array of 400 tubes (N = 20) each 6mm in diameter. The tubes are exposed to saturated steam at pressure of 0.15bar (T_{sat} = 54°C). The tube surface is maintained at a temperature of 25°C. Calculate the condensation rate per unit length of the tubes. The tubes are arranged horizontal in vertical tier of 20 tubes. **(08 Marks)**

Module-5

9 a. Explain briefly the concept of a block body. **(04 Marks)**

b. State :
   i) Kirchoff's law
   ii) Wien's displacement law
   iii) Plnak's law. **(06 Marks)**

c. A hot water radiator of overall dimensions 2 × 1 × 0.2m is used to heat the room at 18°C. The surface temperature of radiator is 60°C and its surface is black. The actual surface of the radiator is 2.5 times the area of its envelope for convection for which the convection coefficient is given by

$$h_c = 1.3(\Delta T)^{1/3}\ W/m^2k$$

Calculate the rate of heat loss from the radiator by convection and radiation. **(06 Marks)**

OR

10 a. define the following :
   i) Solid angle
   ii) Irradiation
   iii) Radiosity
   iv) Radiation shape factor. **(04 Marks)**

b. State and explain Fick's law of diffusion. **(04 Marks)**

c. Calculate the following quantities for an industrial furnace (black-body) emitting radiation at 2650°C.
   i) Spectral emissive power at λ = 1.2μm
   ii) Wavelength at which the emissive power is maximum
   iii) Maximum spectral emissive power
   iv) Total emissive power
   v) Total emissive power of the furnace, if it is treated as gray and diffuse body with an emissivity of 0.9. **(08 Marks)**

* * * * *