USN

10ME63

Sixth Semester B.E. Degree Examination, Dec.2016/Jan.2017

Heat and Mass Transfer

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. ***Use of HMT data handbook is permitted.***

PART – A

1 a. Explain briefly the mechanism of conduction, convection and radiation heat transfer. **(03 Marks)**

b. Derive the three dimensional general heat conduction equation in Cartesian co-ordinates. **(08 Marks)**

c. The wall of a house in a cold region consists of three layers, an outer brick work 20cm thick, an inner wooden panel 1.4cm thick and an intermediate layer made of an insulating material 10cm thick. The inside and outside temperatures of the composite wall are 28^0C and -12^0C respectively. The thermal conductivity of brick and wood are 0.7W/m/K and 0.18 W/mK respectively. If the layer of insulation has a thermal conductivity of 0.023W/mK, find i) The heat loss per unit area of the wall ii) Overall heat transfer coefficient. **(09 Marks)**

2 a. Obtain an expression for temperature distribution and heat flow through a fin of uniform cross section with the end insulated. **(10 Marks)**

b. The aluminum square fins (0.6mm × 0.6mm), 12mm long are provided on the surface of a semi conductor electronic device to carry 2W of energy generated. The temperature at the surface of the device should not exceed 85^0C, when the surrounding is at 35^0C. Given K = 200 W/ m K, h = 15W/m^2 K. Determine the number of fins required to carry out the above duty. Neglect the heat loss from the end of the fin. **(10 Marks)**

3 a. Obtain an expression for instantaneous heat transfer and total heat transfer using lumped heat analysis for unsteady state heat transfer from a body to the surroundings. **(10 Marks)**

b. An Aluminum sphere weighting 6 kg and initially at a temperature of 420^0C is suddenly immersed in a fluid at 18^0C. The convective heat transfer coefficient is 45W/m^2 K. Estimate the time required to cool the sphere to 120^0C. Also find the total heat flow from the sphere to the surroundings when it cools from 300^0C to 120^0C. (For Aluminum, ρ = 2700 kg/m^3, C = 900 J/kg K , K = 200W/m K). **(10 Marks)**

4 a. Using dimensional analysis show that for free convection heat transfer $Nu = B\ Gr^a\ Pr^b$ with usual notations. **(10 Marks)**

b. A vertical plate 4m high and 6m wide is maintained at 60^0C and exposed to atmospheric air at 10^0C. Calculate the heat transfer from both sides of the plate. For air at 35^0C, take K = 0.027W/m K , $\gamma = 16.5 \times 10^{-6}$ m^2/s, Pr = 0.7. **(10 Marks)**

PART – B

5 a. Explain the significance of
i) Reynolds number ii) Prandtl number iii) Grashoff number iv) Stanton number v) Nusselt number. **(10 Marks)**

b. Water flows at a velocity of 12m/s in a straight tube of 60mm diameter. The tube surface temperature is maintained at 70^0C and the flowing water is heated from the in let temperature of 15^0C to an outlet temperature of 45^0C. Taking the physical properties of water at the mean bulk temperate of 30^0C as $\rho = 995.7 kg/m^3$, Cp = 4.174 kJ/kg K, K = 0.61718 W/m K , $\gamma = 0.805 \times 10^{-6}\ m^2/s$ and Pr = 5.42. Calculate i) heat transfer coefficient from the tube surface to the water ii) the heat transferred and iii) the length of the tube. **(10 Marks)**

6 a. Derive the expression for LMTD for a parallel flow heat exchanger. List out the assumptions made. **(10 Marks)**

b. Saturated steam at 140^0C is condensing on the outer surface of a single pass heat exchanger. The overall heat transfer coefficient is $1500 W/m^2$ K. Determine the surface area of the heat exchanger required to heat 2000 kg/h of water from 20^0C to 45^0C. Also determine the rate of condensation of steam in kg/h. Assume the latent heat of steam to be 2145 kJ/kg. **(10 Marks)**

7 a. With a neat sketch, explain the different regimes of pool boiling. **(10 Marks)**

b. Define Mass transfer coefficient. **(05 Marks)**

c. State Fick's law of diffusion. What are its limitations? **(05 Marks)**

8 a. Explain i) Stefan – Boltzman law ii) Wein's displacement law iii) Radiation shield iv) Radiosity v) Black body. **(10 Marks)**

b. Two large parallel plates having emissivity's of 0.3 and 0.6 are maintained at a temperature of 900^0C and 250^0C. A radiation shield having an emissivity of 0.05 on both sides is placed between the two plates. Calculate
i) Heat transfer without shield.
ii) Heat transfer with shield.
iii) Percentage reduction in the heat transfer due to shield.
iv) Temperature of the shield. **(10 Marks)**

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