CBCS SCHEME

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15ME63

Sixth Semester B.E. Degree Examination, July/August 2022
Heat 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 are permitted.

Module-1

1 a. Derive general three dimensional conduction equation in Cartesian co-ordinate system. **(08 Marks)**

b. A furnace wall is made up of three layers of thickness 250mm, 100mm and 150mm with thermal conductivities 1.65, K and 9.5W/m°C respectively. The inside is exposed to gasses at 1250°C with convection co-efficient of 25W/m^{2}K and inside surface is at 1100°C, the outside surface is exposed to air at 25°C with convection coefficient of 12W/m^{2}K. Determine: i) Unknown thermal conductivity ii) Overall heat transfer coefficient iii) All surface temperatures. **(08 Marks)**

OR

2 a. Explain the three basic modes of heat transfer and state the laws governing them. **(05 Marks)**

b. Describe different types of boundary conditions applied to heat conduction problems. **(05 Marks)**

c. A thin metal sphere of diameter 300mm is used to store a liquidified gas at -200°C, to reduce the heat leakage from atmosphere at 30°C, it is insulated by two layers of insulation each 30mm thick. The first layer of insulating material [K = 0.06W/m-K] and second layer has K = 0.6W/m-K. Determine the heat leakage i) When better insulator is next to sphere ii) When better conductor is next to sphere. **(06 Marks)**

Module-2

3 a. Derive an expression for critical thickness of insulation for a cylinder. **(05 Marks)**

b. Derive an expression for temperature distribution in a body at time t during a Newtonian heating or cooling is given by

$$\frac{T - T_\infty}{T_i - T_\infty} = e^{-B_i F_o}$$ **(05 Marks)**

c. A 12m diameter long rod initially at a uniform temperature of 40°C is placed in a medium at 650°C with a convection coefficient of 22W/m^{2}K. Calculate the time required for the bar to reach 255°C. Take K = 20W/m-K, ρ = 580kg/m^3 and C = 1050J/kg-K. **(06 Marks)**

OR

4 a. Derive an expression for temperature distribution and rate of heat transfer for a pinfin, when tip of the fin is insulated. **(08 Marks)**

b. A cylinder of length 1m and diameter 5cm is placed in an atmosphere of 40°C, is provided with 12 longitudinal fins (K = 65W/m°C) 0.75mm thick. The fins protrude 2.5cm from the cylinder surface. The heat transfer coefficient from the cylinder and fins to the ambient air is 20W/m^{2}K calculate:

i) The rate of heat transfer if the surface temperature of the cylinder is 150°C.
ii) Temperature at the centre of the fin.
iii) Effectiveness of the fin.

Assume the heat transfer from the end is negligible. **(08 Marks)**

Module-3

5 a. Explain the numerical analysis applied to two dimensional steady state conduction. **(08 Marks)**

b. Two concentric spheres of 20m and 30m diameter are used to store liquid nitrogen at 120°K in a room at 300K. The space between the spheres is made perfect vacuum. The surfaces are highly polished to attain an emissivity of 0.04. Calculate the rate of evaporation of liquid nitrogen per hour, if the latent heat of nitrogen is 1255kN/kg. **(08 Marks)**

OR

6 a. Explain: i) Kirchoff's law ii) Planks law iii) Wein's displacement law iv) Emmissivity and Emissive power. **(08 Marks)**

b. Calculate the net radiant heat exchange/m^2 area for two large parallel plates at a temperature of 427°C and 27°C respectively. Emmissivity of hot plate is 0.9 and for cold plate is 0.6. If polished alluminium shield is placed between them. Find percentage reduction in heat transfer. Assume emissivity of radiation shield 0.4. Also determine equilibrium temperature of radiation shield. **(08 Marks)**

Module-4

7 a. Explain: i) Velocity boundary layer ii) Thermal boundary layer. **(06 Marks)**

b. Explain the significance of:
   i) Reynolds number
   ii) Prandtl number
   iii) Nusselt number
   iv) Stanton number. **(04 Marks)**

c. A horizontal pipe 30cm in diameter is maintained at 260°C in a room at temperature 20°C. Calculate free convective heat loss per metre length of pipe use the following correlation $N_u = 0.53\ (GrPr)^{0.25}$. **(06 Marks)**

OR

8 a. Using Buckingham's π-theorem, obtain a relation for forced convection heat transfer. **(08 Marks)**

b. Water at a velocity of 1.5m/s enters a 2cm diameter heat exchanger tube at 40°C. The heat exchanger tube wall is maintained at a temperature of 100°C. If the water is heated to a temperature of 80°C in the heat exchanger tube, find the length of the exchanger tube required. **(08 Marks)**

Module-5

9 a. With neat sketch, explain the regims of pool boiling. **(05 Marks)**

b. Explain Film wise and Drop wise condensation. **(04 Marks)**

c. Air free saturated steam at a temperature of 65°C condenses on a vertical outer surface of a 3m long vertical tube maintained at a uniform temperature of 35°C. Assuming film condensation, calculate the average heat transfer coefficient over entire length of the surface. Also calculate the rate of condensate flow. Take outer diameter of tube as 2.5cm. **(07 Marks)**

OR

10 a. Derive an expression for LMTD of counter flow heat exchanger and state the assumptions. **(08 Marks)**

b. Cold fluid at a rate of 1500kg/hr enters a parallel flow heat exchanger at a temperature of 15°C. Hot fluid enters at a rate of 600kg/hr and at a temperature of 100°C. Overall heat transfer coefficient is 60W/m^{2}K and total surface area of heat exchanger is 1.2m^2. Determine the outlet temperature of hot and cold fluid. If the specific heat of hot and cold fluid are 0.5 and 1kJ/kg-K. Also find the rate of heat transfer. **(08 Marks)**

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