CBCS SCHEME

USN

21ME62

Sixth Semester B.E./B.Tech. Degree Examination, Dec.2024/Jan.2025

Heat Transfer

Time: 3 hrs. Max. Marks: 100

Note : 1. *Answer any FIVE full questions, choosing ONE full question from each module.*
2. *Use of Heat transfer Data book and Thermodynamics Data book is permitted.*
3. *Assume any missing data.*

Module-1

1 a. Derive the 3 – Dimensional general heat conduction equation for steady state heat flow in terms of Cartesian co-ordinates. **(10 Marks)**

b. A wall is constructed of several layers. The first layer consists of brick (K = 0.66 w/mK), 25cm thick , the second layer 2.5cm thick mortar (K = 0.7 W/mK), the third layer 10cm thick limestone (K = 0.66 W/mK) and outer layer of 1.25cm thick plaster (K = 0.7 W/mK). The heat transfer coefficients on interior and exterior of the wall fluid layers are 5.8 W/m^2K and 11.6 W/m^2 K 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 the outer layer is at -7°C.

iv) Temperature at the junction between mortar and limestone. **(10 Marks)**

OR

2 a. Derive the temperature distribution equation and heat transfer for a one dimensional conduction through a plane watt without heat generation. **(10 Marks)**

b. Explain the experimental procedure for determining overall heat transfer coefficient for a composite wall made up of three different materials with suitable sketch, tabulation of readings and formulae. **(10 Marks)**

Module-2

3 a. Derive the equations to determine temperature distribution and heat transfer through a pin fin of infinitely long. **(10 Marks)**

b. A mild steel rod (K = 32 W/m °C), 12mm in diameter and 60 mm long with an insulated end is to be used as spine. It is exposed to surroundings with a temperature of 60°C and a heat transfer coefficient of 55 W/m^2°C. If the base temperature of the fin is 95°C, determine

i) Fin efficiency

ii) Temperature at the edge of a spine

iii) Heat transfer rate

iv) Effectiveness of fin. **(10 Marks)**

OR

4 a. Derive temperature distribution equation for lumped parameter analysis of solids for transient heat conduction with negligible internal resistance. **(08 Marks)**

b. What is Biot number and Fourier number with their significance. **(04 Marks)**

c. A 15mm diameter mild steel sphere ($K = 42\ W/m^oC$) is exposed to cooling air flow at 20°C with the convection coefficient $h = 120\ N/m^2\ ^oC$. Determine :
   i) Time required to cool sphere from 550°C to 90°C.
   ii) Instantaneous heat transfer rate 2 minutes after start of cooling.
   iii) Total energy transferred from sphere during first 2 minutes.
   Take $\rho = 7850\ kg/m^3$, $C = 475\ J/kg\ ^oC$, $\alpha = 0.045\ m^2/h$. **(08 Marks)**

Module-3

5 a. Explain the finite difference formulation of one dimensional steady state conduction for a plane wall using energy balance approach. **(10 Marks)**

b. A large plate of thickness L = 4cm, having thermal conductivity $K = 28\ W/m^oC$ in which heat is generated uniformly at a constant rate of $\dot{q}_{gm} = 5 \times 10^6\ W/m^3$. One end of the plate is maintained at 0°C and other end is subjected to environment at $T_\infty = 30^oC$, with heat transfer coefficient of $h = 45\ W/m^2C$. Considering three nodes as two nodes at the boundary and one in the middle. Determine the surface temperature of plate for steady state conditions using finite difference approach. **(10 Marks)**

OR

6 a. State and prove Kirchoff's law of radiation. **(06 Marks)**

b. Explain : i) Stefan Boltzmann law ii) Planck's law iii) Wein's displacement law iv) Black body. **(08 Marks)**

c. Two large parallel plates with $\varepsilon = 0.5$ each are maintained at different temperatures exchanging heat by radiation. Two equally large radiation shields with surface emissivity ($\varepsilon = 0.05$) are introduced between plates. Find the percentage reduction in net radiative heat transfer. **(06 Marks)**

Module-4

7 a. Explain with sketch, development of a velocity boundary layer and thermal boundary layer over a smooth flat plate. **(10 Marks)**

b. Air is at 20°C is flowing over a flat plate which is 200mm wide and 500mm long. The plate is maintained at 100°C. Find the heat loss per hour from the plate if the air is flowing with 2m/s velocity. What will be effect the heat transfer if the flow is parallel to 200mm wide? **(10 Marks)**

OR

8 a. Define the following Dimensionless parameters :
   i) Reynolds number ii) Nusselt number iii) Prandtl number
   iv) Grashoff number v) Stanton number. **(10 Marks)**

b. A sheet metal air duct carries conditioned air at an average temperature of 10°C. The Duct size is 320mm × 200mm and length of the duct exposed to air at 30°C is 15m long. Find the heat gained by air in Duct. Take 200mm side as vertical and top surface of the duct is insulated. Use the following equations :
   $N_u = 0.6\ (Gr\ Pr)^{0.25}$ for Vertical surface
   $N_u = 0.27\ (Gr\ Pr)^{0.25}$ for Horizontal surface. **(10 Marks)**

Module-5

9 a. Explain the different regimes of boiling curves of water. **(10 Marks)**

b. A metal clad heating element of 10 mm dia and of emissivity 0.92 is submerged in water bath horizontally. If the surface temp of metal is 260°C, under steady boiling conditions, calculate the power dissipation per unit length for the heater water is exposed to atmospheric pressure and is at a uniform temperature. **(10 Marks)**

OR

10 a. Derive the expression for LMTD for a parallel flow heat exchanger. **(10 Marks)**

b. Steam condenses at atmospheric pressure on the external surface of tubes of condenser. The tubes are 12 in number and each is 30 mm dia and 10 m long. The inlet and outlet temperatures of cooling water flowing inside tubes are 25°C and 60°C.; if the flow rate is 1.1 kg/s. Calculate :

i) Rate of condensation of steam.
ii) Mean overall heat transfer coefficient based on inner surface area.
iii) Number of Transfer Units (NTU).
iv) Effectiveness of the condenser. **(10 Marks)**

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