

CBCS SCHEME

15ME63

Sixth Semester B.E. Degree Examination, Aug./Sept.2020 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 and Mass Transfer data handbook is permitted.

Module-1

- 1 a. Derive the 3-D heat conduction equation in Cartesian coordinate system for an isotropic material. Also write special forms of 3-D heat conduction equation. (08 Marks)
- b. A furnace wall is made up of three layers of thickness 250 mm, 100 mm, 150 mm with thermal conductivities of 1.65, K, 9.2 W/m-K respectively. The inside is exposed to gases at 1250°C with convection coefficient of 25 W/m²-K and outside surface is exposed to air at 25°C with convection coefficient of 12 W/m²-K, inside surface is maintained at 1100°C. Determine:
- The unknown thermal conductivity
 - Overall heat transfer coefficient
 - All surface temperatures. (08 Marks)

OR

- 2 a. Explain the modes of heat transfer with corresponding governing laws. (06 Marks)
- b. Explain the three kinds of boundary conditions to solve conduction problems. (04 Marks)
- c. A wall of steam boiler furnace is made of layers of fire clay of thickness 12.5 cm ($K_1 = 0.28 + 0.00023T$ W/m°C) and red brick of 50 cm ($K_2 = 0.7$ W/m°C) where T is in °C. The inside surface temperature of fire clay is 1100°C and outside brick wall temperature is 50°C. Calculate the amount of heat loss per unit area of the furnace wall and the temperature at the interface. (06 Marks)

Module-2

- 3 a. What do you mean by critical thickness of insulation? Derive an expression for critical thickness of insulation for cylinder. (05 Marks)
- b. In a thermal conductivity measuring experiment two identical long rods are used. One rod is made of aluminium ($K = 200$ W/m-K). The other rod is specimen. One end of both the rods is fixed to a wall at 100°C, while the other end is suspended in air at 25°C. The steady temperature at the same distance along the rods were measured and found to be 75°C on aluminium and 60°C on specimen rod. Find thermal conductivity of the specimen. Assume that the fin is insulated at the tip. (05 Marks)
- c. Show that the temperature distribution under lumped analysis is given by, $\frac{T - T_\infty}{T_i - T_\infty} = e^{-Bi.Fo}$
where T_i is the initial temperature and T_∞ is the surrounding temperature. (06 Marks)

OR

- 4 a. What is the main purpose of fins? Define fin efficiency and fin effectiveness. (04 Marks)
- b. What are Heisler charts? Explain their significance in solving transient conduction problems. (04 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and/or equations written eg. 42+8=50, will be treated as malpractice.

- c. A 12 mm diameter mild steel sphere at 540°C is exposed to cooling air flow at 27°C and heat transfer coefficient of $114 \text{ W/m}^2\text{-K}$. Find:
- The time required to cool the sphere from 540°C to 95°C
 - Instantaneous heat transfer rate, two minutes after start of cooling
 - Total heat transferred from the sphere during first two minutes.
- Properties of mild steel are: $\rho = 7850 \text{ kg/m}^3$, $C = 475 \text{ J/kg-K}$ and $\alpha = 0.045 \text{ m}^2/\text{hr}$.

(08 Marks)

Module-3

- 5 a. Why numerical methods are preferred over analytical methods? List the numerical methods which are used in solving heat conduction problems. (04 Marks)
- b. The boundary temperatures of a thin plate are as shown in Fig.Q5(b). Determine the temperature at the centre of the plate.

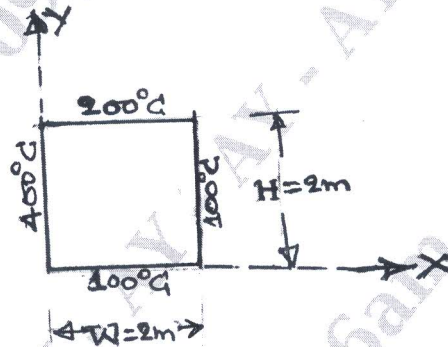


Fig.Q5(b)

(06 Marks)

- c. Explain:
- Kirchhoff's law
 - Plank's law
 - Wien's displacement law

(06 Marks)

OR

- 6 a. How is Laplace equation for 2D heat conduction approximated to the finite difference equations? (08 Marks)
- b. Calculate the net radiant heat exchange per unit area for two large parallel plates at temperature of 427°C and 27°C respectively. Take emissivity of hot plate and cold plates are 0.9 and 0.6 respectively. If a polished aluminium shield is placed between them, find percentage reduction in the heat transfer. Take emissivity of shield as 0.4. (08 Marks)

Module-4

- 7 a. With the help of dimensional analysis obtain the fundamental relation between dimensionless numbers required for
- Forced convection
 - Natural convection. (10 Marks)
- b. Water at a velocity of 1.5 m/s enters a 2 cm 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. (06 Marks)

OR

- 8 a. Define and explain the physical significance of the following dimensionless numbers:
(i) Grashoff number
(ii) Reynolds number (04 Marks)
- b. For fluid flow over a flat plate, sketch (i) Velocity boundary layer (ii) Thermal boundary layer. Clearly mention salient points on the figure. (04 Marks)
- c. A tube of 0.036 m OD and 40 cm length is maintained at a uniform temperature of 100°C. It is exposed to air at a uniform temperature of 20°C. Determine the rate of heat transfer from the surface of the tube when (i) the tube is vertical (ii) the tube is horizontal. (08 Marks)

Module-5

- 9 a. What is the importance of NTU effectiveness method? Derive an expression for the effectiveness of a parallel flow heat exchanger. (08 Marks)
- b. Sketch pool boiling curve for water and explain the various regimes in boiling heat transfer. (08 Marks)

OR

- 10 a. List the assumptions made in Nusselt's theory of laminar film condensation on a plane vertical surface. (04 Marks)
- b. Saturated steam at 80°C condenses as a film on a vertical plate at a temperature of 70°C. Calculate the average heat transfer coefficient and the rate of steam condensation per hour. Assume that the latent heat of vaporization at 80°C as 2309 kJ/kg. (06 Marks)
- c. An oil cooler for a large diesel engine is to cool engine oil from 60 to 45°C using sea water at an inlet temperature of 20°C with a temperature rise of 15°C. The design load $Q = 140$ KW and the mean overall heat transfer coefficient based on the outer surface area of the tubes is 70 W/m²°C. Calculate the heat transfer surface area for single pass counter flow and parallel flow arrangement. (06 Marks)
