



CBCS SCHEME

21AU51

Fifth Semester B.E./B.Tech. Degree Examination, June/July 2026 Heat and Mass 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 is permitted.*

Module-1

- 1 a. What are the three basic modes of heat transfer? State the laws governing them. (10 Marks)
- b. A horizontal steel pipe of 50 mm diameter maintained at 60°C is kept in a large room at 22°C. Assuming surface emissivity of steel as 0.8 and heat transfer coefficient of air as 6.5 W/m² °C. Calculate the total heat lost by the pipe per unit length. (10 Marks)

OR

- 2 a. Derive 3 dimensional conduction equation in Cartesian coordinates. (10 Marks)
- b. A 600 mm outer diameter sphere storing liquid is provided with insulating layers, a high temperature insulation of conductivity 0.35 W/m K and a low temperature insulation of thermal conductivity 0.07 W/m K. The thickness of former is 100 mm. The temperature drop across the high temperature is required to be 2.5 times that across the low temperature insulation. What should be the thickness of latter? (10 Marks)

Module-2

- 3 a. Derive an expression for the temperature distribution for a long fin of uniform cross section with insulated tip. (10 Marks)
- b. A longitudinal copper fin (K = 280 W/m°C) 600 mm long and 5 mm diameter is exposed to air stream at 20°C. The convective heat transfer coefficient is 20 W/m² °C. If the fin base temperature is 150°C. determine :
- i) The heat transferred
- ii) The efficiency of the fin. (10 Marks)

OR

- 4 a. Derive the expression for the temperature distribution for the lumped heat analysis. (10 Marks)
- b. An aluminum rod which is initially at a temperature of 200°C is exposed to air at 30°C. The diameter of the pipe is 10 cm. Find the time required for the rod to reach a temperature of 50°C. Assume that the surface convective heat transfer coefficient is 50 W/m²K. (10 Marks)

Module-3

- 5 a. Using dimensional analysis, show that $Nu = f(Gr, Pr)$ for natural convection. (12 Marks)
- b. Find the heat loss from both sides of a hot square plate 50 cm × 50 cm at 100°C, exposed to atmosphere at 20°C, if the plate is kept vertical. Use the following relation.
- $Nu = 0.13 (Gr.Pr)^{1/3} \rightarrow$ vertical position at 60°C, take $\rho = 1.06 \text{ kg/m}^3$, $K = 0.028 \text{ W/mK}$
- $\gamma = 18.97 \times 10^{-6} \text{ m}^2/\text{s}$, $C_p = 1.008 \text{ kJ/kg-K}$. (08 Marks)

OR

- 6 a. Define the following dimensionless numbers and mention their significance, writing relevant equations:
- (i) Prandtl number
 - (ii) Reynolds number
 - (iii) Nusselt number
 - (iv) Stanton number
- (10 Marks)
- b. Air at 27°C is moving at 0.3 m/s across a 100 W electric bulb at 127°C . If the bulb is approximated by a 10 cm diameter and 1 m high cylinder, estimate the heat transfer rate and percentage of power lost due to convection. At 77°C , take $\text{Pr} = 0.697$, $k = 0.03\text{ W/mK}$, $\gamma = 2.08 \times 10^{-5}\text{ m}^2/\text{s}$.
- (10 Marks)

Module-4

- 7 a. Derive the expression for effectiveness of the parallel flow heat exchanger by NTU method.
- (10 Marks)
- b. A saturated steam at 120°C is condensing on the outer surface of a single pass heat exchanger. The overall heat transfer coefficient is $1600\text{ W/m}^2\text{ }^{\circ}\text{C}$. Determine the surface area of heat exchanger required to heat 2000 kg/hr of water from 20°C to 90°C . Also determine the rate of condensation of steam in kg/hr . Assume latent heat of steam to be 2195 KJ/kg .
- (10 Marks)

OR

- 8 a. Explain the different regimes of boiling with a graph.
- (10 Marks)
- b. A vertical square plate $30 \times 30\text{ cms}$ is exposed steam at atmospheric pressure. The plate temperature is 98°C . Calculate the heat transfer and mass of steam condensed per hour.
- (10 Marks)

Module-5

- 9 a. State :
- i) Stefan – Boltzmann Law
 - ii) Kirchoff's Law
 - iii) Planck Law
 - iv) Wein's displacement Law
- (10 Marks)
- b. The effective temperature of a body having an area of 0.12 m^2 is 527°C . Calculate the following :
- i) The total rate of energy emission
 - ii) Intensity of normal radiation
 - ii) Wavelength of maximum monochromatic emissive power.
- (10 Marks)

OR

- 10 a. Derive an expression for heat transfer between two infinite parallel planes.
- (10 Marks)
- b. Determine the rate of heat loss by radiation from a steel tube of outside diameter 70 mm and 3 m long at a temperature of 227°C . If the tube is located within a square brick conduit of 0.3 m side and at 27°C . Take $\epsilon_{\text{steel}} = 0.79$ and $\epsilon_{\text{brick}} = 0.93$.
- (10 Marks)

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