CBCS SCHEME

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18AU62

Sixth Semester B.E. Degree Examination, June/July 2025
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Explain and define Fourier's law of heat conduction. What is thermal conductivity? How does it vary with temperature? **(10 Marks)**

b. A plane wall is 150 mm thick and its wall area is 4.5 m^2. If its conductivity is 9.35 W/m°C and surface temperatures are steady at 150°C and 45°C. Determine :
   (i) Heat flow across plane wall.
   (ii) Temperature gradient in the flow direction **(10 Marks)**

OR

2 a. Derive general heat conduction equation in Cartesian coordinate. **(10 Marks)**

b. Derive an expression for heat transfer through composite walk, considering three layers of wall. **(10 Marks)**

Module-2

3 a. Explain lumped system analysis. Derive Biot and Fourier number. **(10 Marks)**

b. A 120 mm diameter apple $(\rho = 990\ kg/m^3, C = 4170\ J/kg°C, K = 0.58\ W/m°C)$, approximately spherical in shape is taken from a 25°C environment and placed in a refrigerator where temperature is 6°C and average convective heat transfer coefficient over the surface is 12.8 $W/m^2\,°C$. Determine the temperature at the centre of the apple after a period of 2 hours. **(10 Marks)**

OR

4 a. Explain fin effectiveness and fin efficiency. **(10 Marks)**

b. A rod of 12 mm dia is used as a fin of length 0.08 m. The material conductivity is 15.5 W/mK. The convection co-efficient is 25 W/m^2K. Compare the heat flow if the same volume is used for two fins of same length. **(10 Marks)**

Module-3

5 a. Explain the concept of velocity boundary layer. **(10 Marks)**

b. The resistance R experienced by a partially submerged body depends upon the velocity V, length of body ℓ, viscosity of the fluid μ, density of the fluid ρ and gravitational acceleration g. Obtain dimensionless expression for R. **(10 Marks)**

OR

6 a. Define the following dimensionless numbers and mention their physical significance :
(i) Reynolds
(ii) Prandtl
(iii) Nusselt
(iv) Stanton (10 Marks)

b. Air is flowing over a flat plate 5 m long and 2.5 m wide with a velocity of 4 m/s at 15 °C. If $\rho = 1.208$ kg/m^3 and $\nu = 1.47 \times 10^{-5}$ m^2/s. Calculate
(i) Length of plate over which the boundary layer is laminar and thickness.
(ii) Shear stress at location where boundary layer ceases to be laminar.
(iii) Total drag force on both sides on that portion of plate where the flow is laminar. (10 Marks)

Module-4

7 a. Explain the regimes of pool boiling. (10 Marks)
b. Mention the assumptions of Nusselt's analysis of film condensation. (10 Marks)

OR

8 a. Derive an expression of LMTD for parallel flow heat exchanger. (10 Marks)
b. In a certain double pipe heat exchanger hot water flows at a rate of 5000 kg/h and gets cooled from 95 °C to 65 °C. At the same time 5000 kg/h of cooling water at 30 °C enters the heat exchanger. The flow conditions are such that overall heat transfer co-efficient remains constant at 2270 W/m^{2}K. Determine the heat transfer area required and effectiveness, assuming 2 streams are parallel flow. Assume C_P = 4.2 KJ/kg K for both. (10 Marks)

Module-5

9 a. Explain Stefan-Boltzman law and Kirchoff's 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) Total rate of energy emission.
(ii) Intensity of normal radiation.
(iii) Wavelength of max monochromatic radiation (10 Marks)

OR

10 a. Derive an expression for radiation heat exchange between two block surfaces. (10 Marks)
b. Derive an expression for intensity of radiation. (10 Marks)

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