CBCS SCHEME

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18AU62

Sixth Semester B.E. Degree Examination, Dec.2024/Jan.2025
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 handbook is permitted.

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.

Module-1

1 a. Define:
(i) Thermal conductivity (ii) Thermal diffusivity
(iii) Overall heat transfer coefficient (iv) Thermal Contact Resistance **(08 Marks)**

b. Derive the general three dimensional heat conduction equation in Cartesian coordinate and state the assumptions made. **(12 Marks)**

OR

2 a. What do you mean by boundary conditions of 1st, 2nd and 3rd kind? **(08 Marks)**

b. The wall of a house in a cold region consists of three layers, an outer brick of 20 cm thick, an inner wooden panel 1.4 cm thick and an intermediate layer made of an insulating material 10 cm thick. The inside and outside temperatures of composite wall all 28°C and −12°C respectively. The thermal conductivity of brick and wood are 0.7 W/mK and 0.18 W/m.K respectively. If the layer of insulation has a thermal conductivity of 0.023 W/m.K, find heat loss per unit area of the wall. **(12 Marks)**

Module-2

3 a. Obtain an expression for temperature distribution and heat flow through a rectangular fin, when the end of the fin is insulated. **(08 Marks)**

b. Differentiate between effectiveness and efficiency of fin. **(04 Marks)**

c. A turbine blade 6 cm long and having a cross sectional area 4.65 cm^2 and perimeter 12 cm, is made of stainless steel (K = 23.3 W/mK). The temperature at the root is 500°C. The blade is exposed to a hot gas at 870°C. The heat transfer coefficient between the blade surface and gas is 44.2 $W/m^2.K$. Determine the temperature distribution and rate of heat flow at the root of the blade. Assume the tip of the blade to be insulated. **(08 Marks)**

OR

4 a. Derive an expression for temperature distribution in a lumped system. **(08 Marks)**

b. Explain the physical significance of Biot and Fourier number. **(04 Marks)**

c. The average heat transfer coefficient for flow of 100°C air over a flat plate is measured by observing the temperature time history of a 3 cm thick copper slab exposed to 100°C air, in one test run the initial temperature of slab was 210°C and in 5 min the temperature is decreased by 40°C. Calculate the heat transfer coefficient for this case. Assume $\rho = 9000\ kg/m^3$, c = 0.38 kJ/kgK, K = 370 W/mK. **(08 Marks)**

Module-3

5 a. Explain with sketches:
(i) Velocity boundary layer
(ii) Thermal boundary layer **(10 Marks)**

b. Air flows over a flat plate at 30°C, 0.4 m wide and 0.75 m long with a velocity of 20 m/s. Determine the heat transfer from the surface of the plate assuming plate is maintained at 90°C. Use $Nu_L = 0.664\ Re^{0.5}\ Pr^{0.33}$ for laminar, $Nu_L = [0.036\ Re^{0.8} - 0.836]Pr^{0.333}$ for turbulent. **(10 Marks)**

OR

6 a. Explain the physical significance of the following dimensionless numbers:
(i) Reynold's number (ii) Prandtl number
(iii) Nusselt number (iv) Stanton number **(08 Marks)**

b. Obtain an empirical expression in terms of dimensionless numbers for heat transfer coefficient in case of forced convection heat transfer. **(12 Marks)**

Module-4

7 a. Derive an expression for LMTD of parallel flow heat exchanger. **(10 Marks)**

b. A counter flow double pipe (tube-in-tube) heat exchanger using superheated steam is used to heat the water at a rate of 3 kg/s. The steam enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of water are 30°C and 80°C respectively. The overall heat transfer coefficient is 820 W/m^2K. Calculate the heat transfer area required. What would be the increase in surface area of fluid, if fluid flow is parallel? Take C_p of water s 4187 J/kgK. **(10 Marks)**

OR

8 a. Explain different regimes of pool boiling with neat sketches. **(10 Marks)**

b. Find the Nusselt's heat transfer coefficient and mass of condensate per hour if a vertical square plate of side 40 cm is exposed to steam at atmospheric pressure. The plate is maintained at an uniform temperature of 96°C. **(10 Marks)**

Module-5

9 a. Define the terms used in radiation heat transfer with appropriate diagram:
(i) Thermal radiation (ii) Absorptivity (iii) Transmissivity
(iv) Opaque body (v) Black body **(10 Marks)**

b. Briefly explain the following:
(i) Stefan-Boltzmann law (ii) Kirchoff's law (iii) Wein's displacement law
(iv) Plank's law (v) Lamberts law **(10 Marks)**

OR

10 a. Prove that emissive power of the black body in hemispherical enclosures in π terms of intensity of radiation. **(12 Marks)**

b. Emissivities of two large parallel plates maintained at 800°C and 300°C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per square metre for these plates. **(08 Marks)**

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