CBCS SCHEME

USN | | | | | | | | | | | **15AU62**

Sixth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Heat and Mass Transfer

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing one full question from each module.
2. Use of HMT and TD data hand book 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 the three basic modes of heat transfer and the governing laws with supporting relationship. **(09 Marks)**

b. Air at 23°C blows over a hot plate made of carbon steel at 260°C. the plate is 0.6m × 0.75m and 2cm thick. If 300W is lost from the plate surface by radiation, calculate the heat transfer and inside plate temperature. Assume convective heat transfer coefficient as $25 W/m^2 °C$ and K for carbon steel as 43W/m°C. **(07 Marks)**

OR

2 a. Starting from the fundamental, deduce general form of one dimensional heat conduction equation in Cartesian coordinates and arrive at Fourier equation. **(08 Marks)**

b. An aircraft heat exchanger has a minimum wall temperature of 810K. The hot side and the cold side heat transfer coefficient are $200 W/m^2K$ and $400 W/m^2K$ respectively. Determine the maximum permissible unit thermal resistance per m^2 area of the metallic walls separating the hot gas from the cold gas, if hot gas temperature is 1200K and coolant temperature is 300K. **(08 Marks)**

Module-2

3 a. Derive an expression for the heat loss per m^2 of the surface area for a furnace wall when the thermal conductivity varies with temperature according to the following relation, $K = (\alpha + \beta T^2)$ W/m°C where T is in °C, and $K_m = \frac{-1}{T_1 - T_2}\int_{T_1}^{T_2} K \, dT$. **(06 Marks)**

b. Define critical thickness of insulation and write its expression for a cylinder and a sphere. **(04 Marks)**

c. A Structure uses an aluminum alloy fin of 3mm thickness and 20mm length protruding from a wall. The base is at 400°C and the ambient temperature is 25°C. Calculate the heat loss from the fin per unit depth of material. Take $h = 326 W/m^2K$ and K = 11 W/mK. Assume that the fin is sufficiently long. **(06 Marks)**

OR

4 a. What do you understand by lumped system analysis? **(02 Marks)**

b. Derive an expression for total heat transfer rate in terms of Biot and Fourier numbers if $\frac{T(t) - T_\infty}{T_0 - T_\infty} = e^{-BiF_0}$ **(08 Marks)**

c. A steel ball at uniform temperature of 450°C is suddenly exposed to air at 100°C. The ball attains a temperature of 150°C after 81 minutes. Assume surface heat transfer coefficient as $12 W/m^2K$, $\rho = 7860 kg/m^3$, $C_p = 461$ J/kg K. Neglecting internal temperature gradient, estimate the ball diameter. **(06 Marks)**

Module-3

5 a. Explain with a sketch, the concept of thermal boundary layer. Deduce a general expression for (i) local and mean (average) heat transfer coefficient (ii) Heat transfer for flow over a flat plate. **(08 Marks)**

b. Estimate the drag force acting on the plate over the width W = 2m when atmospheric air at 375K flows with a velocity of u_∞ = 4m/s along the flat plate L = 1m long, maintained at a uniform temperature of 325K. The average heat transfer coefficient is 8W/m^2 °C. Use the Reynolds – Colburn analogy, $\frac{C_m}{2} = \frac{h_m}{\rho C_p u_\infty} P_r^{\frac{2}{3}}$. **(08 Marks)**

OR

6 a. Obtain the fundamental relationship between Nusselt, Prandtl and Grashaff numbers using dimensional analysis. **(08 Marks)**

b. A horizontal pipe 30cm in diameter is maintained at 260°C in a room whre ambient air is at 20°C. Calculate the free convective heat loss per meter length of pipe. Properties of air at mean temperature are, P_r = 0.684 ; √ = 27.8×10^{-4} m^2/s ; K = 0.035 W/mK. Use Nu = 0.53 $(Gr.Pr)^{1/4}$. **(08 Marks)**

Module-4

7 a. Derive am expression for effectiveness by NTU method for a parallel flow heat exchanger. **(08 Marks)**

b. In a Diesel plant a single shell pass, six tube pass heat exchanger is used to cool hot oil from 100°C to 50°C using water at 22°C. Mass flow rates of hot and cold liquids are 1.2kg/s and 0.9 kg/s respectively. Take over all heat transfer coefficient, U_o = 250W/m^2°C, C_{ph} = 2.1 kJ/kg°C ; C_{pc} = 4.18 kJ/kg°C. Find the heat transfer area. **(08 Marks)**

OR

8 a. Define filmwise and dropwise condensation. State the assumptions made in Nusselt theory of film condensation on vertical surfaces. **(08 Marks)**

b. Define pool boiling and sketch different regimes of pool building using an h v/s ΔT plot. **(04 Marks)**

c. Air free saturated stream at T_v = 100°C condenses on the outer surface of 296 horizontal tubes of 130mm OD arranged in a 16×16 array tube surfaces are maintained at a uniform temperature, T_w = 60°C. Determine the average heat transfer coefficients. Take physical properties of water at T_f = as K_c = 0.668 W/m°C, μ_c = 0.355 × 10^{-3} kg/m.s, ρ_1 = 974 kg/m^3, h_{fg} = 2309 kJ/kg. **(04 Marks)**

Module-5

9 a. State and explain :
(i) Planck's distribution law (ii) Lambert's cosine law (ii) Stefan Boltzman. **(09 Marks)**

b. The temperature of a block surface 0.2m^2 area is 540°C. Calculate :
i) The total rate of energy emission
ii) The intensity of normal radiation
iii) The wave length of maximum monochromatic emissive power **(07 Marks)**

OR

10 a. Obtain an expression for rate of heat transfer when a radiation shield is introduced between two parallel plates. **(08 Marks)**

b. Two large plates at T_1 = 1000K and T_2 = 800K have emissivities ε_1 = 0.6 and ε_2 = 0.8 respectively. A radial shielding having an emissivity 0.1 On one side and 0.05 on the otherside is placed between the plates. Calculate the heat transfer by radiation/m^2 with and without the radiation shield. **(08 Marks)**