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B. E. (Sixth Semester) Examination, Nov.-Dec. 2018

(New Scheme)

(Branch : Mech. & Automobile)

HEAT & MASS TRANSFER

Time Allowed : Three hours

Maximum Marks : 80

Minimum Pass Marks : 28

Note *: Part (a) of each question is compulsory and solve any one part from (b) and (c). Use of HMT data book is permitted for formula and properties.*

Unit - I

1. (a) State Fourier law of conduction 2

(b) Derive generalized heat conduction equation for cylindrical co-ordinates. 14

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(c) A stainless steel wire (conductivity = 20 w/m-deg and resistivity = 70 μ ohm-cm) of length 2 m and diameter 2.5 mm is submerged in a fluid at 50°C and an electric current of intensity 300 amps passes through it. If conductance at the wire surface is 4 kW/m^2-deg, workout the steady state temperature at the centre and at the surface of the wire. 14

Unit - II

2. (a) Define fin effectiveness and fin efficiency. 2

(b) Prove that :

$$\frac{T - T_\infty}{T_0 - T_\infty} = e^{-B_i \cdot F_o},$$

where T = temperarure varies with time

T_∞ = Ambient temperature

T_0 = Uniform temperature 14

(c) A plate fin of 10 mm thickness and 80 mm length is dissipating heat from a surface at 190°C. The fin is exposed to air at 25°C with a convective

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coefficient of 22 W/m°- deg. If thermal conductivity of the fin material is 200 W/m-deg, determine the heat dissipation. Consider 1 m width of fin.

To increase the heat dissipation, the following two alternatives have been suggested with the same material volume.

(i) Split the fin into two fins of 5 mm thickness each.

(ii) Single fin 5 mm thick and 160 mm long.

Which will be the better choice?

The fins may be considered short fin with tip insulated. 14

Unit - III

3. (a) Write the physical significance of Grashof number and Prandtl number. 2

(b) Prove that : 14

$Nu = f(Gr \cdot Pr)$ for free convection.

(c) Air at 2 bar and 40°C is heated as it flows through a 30 mm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at 100°C all

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along the length fo tube, make calculations for the heat transfer per unit length of the tube. Proceed to calculate the increase in bulk temperature over one metre length of the tube.

Use the following correlation

$$Nu = 0{\cdot}023\ Re^{0.8}\ Pr^{0.4}$$

and take the following thermophysical properties of air at the average film temperature of 70°C.

$\mu = 20{\cdot}6 \times 10^{-6}$ Ns/m^2

Cp = 1·009 kJ/kg-deg

K = 0.0297 W/m-deg and 14

Pr = 0.694

Unit - IV

4. (a) State Fick's law of diffusion. 2

(b) (i) Explain boiling regimes with neat sketch. 7

(ii) A copper pan of 35 cm diameter contains water and its bottom surface is maintained at 115°C by an electric heater. Calculate the power required to boil water in this pan and

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the rate at which water evaporates from the pan due to the boiling process. 7

(c) Air at 20°C flows past a tray full of water with a velocity of 2·5 m/s. Calculate the evaporation rate of water if temperature on the water surface is 15°C. The tray measures 25 cm along the flow direction and its width is 40 cm.

The moving air has a total pressure of 1·01 bar and the partial pressure of water associated with it is 0.0075 bar. Take the following physical properties of air. 14

Density $\delta = 1.205\ kg/m^3$

Kinematic viscosity $\nu = 15{\cdot}06 \times 10^{-6}\ m^2/s$

Diffusivity $D = 0{\cdot}15\ m^2/hr$

Unit - V

5. (a) State Stefan-Boltzman law. 2

(b) A counter flow heat exchanger is used to cool 2000 kg/hr of oil (Cp = 2·5 kJ/kg K) from 105°C to 30°C by the use of water entering at 15°C. If the overall heat transfer coefficient is expected to be 1·5 kW/m² K, make calculations for the water

flow rate, the surface area required and the effectiveness of heat exchanger. Presume that the exit temperature of the water is not to exceed 80°C. Use NTU effectiveness approach. 14

(c) Determine the net heat exchange between areas A_1 and A_2 which are perpendicular but do not share the common edge (Fig. 5a). The relevant data is -

Surface A_1 :

T_1 = 650 K and ϵ_1 = 0.8

Surface A_2

T = 450 K and ϵ_2 = 0.85 14