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BME-027

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

00390

Term-End Examination

June, 2016

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Answer any **seven** questions. All questions carry equal marks. Use of scientific calculator is permitted. Assume, if any data is missing.*

1. (a) What is meant by thermal resistance ? Explain the electrical analogy for solving heat transfer problems.

(b) Calculate the heat transfer rate per m^2 area by radiation between the surfaces of two long cylinders having radii 100 mm and 50 mm respectively, the smaller cylinder being in the larger cylinder. The axes of the cylinders are parallel to each other and are separated by a distance of 20 mm. The surfaces of the inner and the outer cylinders are maintained at 127°C and 27°C respectively. The emissivity of both the surfaces is 0·5. Assume the medium between the two cylinders is non-absorbing. *5+5*

2. (a) Discuss the critical thickness of insulation and its importance in engineering practice.

(b) Assuming the sun to be a black body emitting radiation with maximum intensity at $\lambda = 0{\cdot}49\ \mu m$, calculate the following :

(i) the surface temperature of the sun, and

(ii) the heat flux at the surface of the sun. *5+5*

3. (a) Draw the temperature gradient through a plane wall when the thermal conductivity

(i) remains constant with increase in temperature.

(ii) increases with an increase in temperature.

(b) A mild steel tank of a wall thickness 12 mm contains water at 95°C. The thermal conductivity of mild steel is 50 W/m °C and the heat transfer coefficients for inside and outside the tank are 2850 W/m^2 °C and 10 W/m^2 °C respectively. If the atmospheric temperature is 15°C, calculate :

(i) The rate of heat loss per m^2 of the tank surface area;

(ii) The temperature of the outside surface of the tank. *5+5*

4. (a) Define Reynolds number and Prandtl number. Explain their importance in convective heat transfer.

(b) The inner surface of a plane brick wall is at 60°C and the outer surface is at 35°C. Calculate the rate of heat transfer per m^2 of surface area of the wall, which is 220 mm thick. The thermal conductivity of the brick is 0·51 W/m °C. *5+5*

5. (a) Explain the concept of black body and grey body in radiation terminology.

(b) Determine the heat flow across a plane wall of 10 cm thickness with a thermal conductivity of 8·5 W/mK, when the surface temperatures are steady and at 200°C and 50°C. The wall area is 2 m^2. Also find the temperature gradient in flow direction. *5+5*

6. (a) Define Fick's first and second law of diffusion. Describe the various mechanisms of mass transfer.

(b) Calculate the approximate Reynolds number and state, if the flow is laminar or turbulent for a 10 m long yatch sailing at 13 km/hr in sea water, $\rho = 1000$ kg/m^3, and $\mu = 1{\cdot}3 \times 10^{-3}$ kg/m.s. *5+5*

7. (a) Define the Fourier number and Biot number for mass number.

(b) Water is boiled at a rate of 30 kg/hr in a copper pan, 30 cm in diameter, at atmospheric pressure. Estimate the temperature of the bottom surface of the pan, assuming nucleate boiling conditions. Also determine the peak heat flux. *5+5*

8. (a) State the modes of mass transfer with suitable examples.

   (b) A black body at 727°C emits radiation. Calculate the wavelength at which the radiation from the body becomes maximum. *5+5*

9. (a) Define the following :

   (i) Mass fraction

   (ii) Mole fraction

   (iii) Molar concentration

   (iv) Mass flux

   (v) Molar flux

   (b) Estimate the diffusion rate of water from the bottom of a test tube 10 mm in diameter and 15 cm long into dry atmospheric air at 25°C.

   Given : $D_{AB} = 0{\cdot}256 \times 10^{-4}$ m^2/sec. *5+5*

10. (a) What is Wien's displacement law ? What is a diffuse body ?

   (b) Prove that the shape factor of a hemispherical bowl of diameter D with respect to itself is 0·5. *5+5*