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BME-027

B.Tech. MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

00903

Term-End Examination

June, 2018

BME-027 : HEAT AND MASS TRANSFER

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt any **five** questions. All questions carry equal marks. Use of scientific calculator is permitted. Assume suitable data, if any.*

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

(b) The interior of a refrigerator having inside dimensions of 50 cm × 50 cm base area and 1 m high is to be maintained at 7°C. The walls of the refrigerator are constructed of two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. If the average heat transfer coefficients at the inner and outer surfaces are 11·61 W/m^2K and 14·53 W/m^2K respectively, estimate the rate at which heat must be removed from the interior to maintain the specified temperature. What is the temperature at the surface of the wall if the outside temperature is 28°C ? The thermal conductivities of mild steel and glass wool are 46·52 W/mK and 0·046 W/mK respectively. *4+10*

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

(b) A 5 cm diameter steel pipe is to be insulated by using two layers, one of asbestos (k = 0·145 W/mK) and other of magnesia (k = 0·069 W/mK) each having a thickness of 5 cm. Find the ratio of heat loss when asbestos is inside to that when asbestos is outside. Assume that the temperature drop across the composite insulation remains unchanged. *4+10*

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

(i) remains constant with increase in temperature.

(ii) increases with increase in temperature.

(b) Air at 20°C and at atmospheric pressure is flowing over a flat plate at a velocity of 3 m/s. It the plate is 30 cm wide and at 60°C, calculate the following quantities at x = 30 cm, from the leading edge : *4+10*

(i) Boundary layer thickness

(ii) Local skin friction co-efficient

(iii) Average skin friction co-efficient

(iv) Local shear stress, and

(v) Average shear stress.

The properties of air at mean temperature of 40°C are

$\rho = 1 \cdot 128$ kg/m^3,

$\mu = 19 \cdot 12 \times 10^{-6}$ Pa.sec

$C_p = 1 \cdot 005$ kJ/kg K,

$k = 2 \cdot 76 \times 10^{-2}$ W/mK.

4. (a) Derive an expression for temperature distribution in a slab of thickness 'b' when its two faces are at temperatures t_1 and t_2, the thermal conductivity varies linearly with temperature according to

$k = k_0 (1 + \alpha t)$

where 'α' is a constant.

Assume one-dimensional steady state heat condition with no heat generation.

(b) The Sun emits maximum radiation at a wavelength of $\lambda = 0 \cdot 52$ micron. Assuming the Sun as a black body, find the surface temperature of the Sun and emissive power at that temperature. 7+7

5. (a) Define Reynolds number, Nusselt number, Prandtl number, and Stanton number. Explain their importance in convective heat transfer.

(b) In a heat exchanger, water flows through a long 2·2 cm ID copper tube at a bulk velocity of 2 m/sec and is heated by steam condensing at 150°C on the outside of the tube. The water enters at 15°C and leaves at 60°C. Find the heat transfer co-efficient for water. 7+7

6. (a) Estimate the diffusion rate of water from the bottom of a test tube 1·5 cm in diameter and 15 cm long into dry atmosphere at 25°C. Take diffusivity of water in air as 0·256 cm^2/sec and saturation pressure of water at 25°C = 0·0316 bar.

(b) A small body at 47°C is placed in a large furnace whose walls are maintained at 1200 K. The total absorptivity of the small body varies with temperature of the incident radiation as follows :

T (K)	320 K	500 K	1200 K
α	0·78	0·67	0·55

Find the rate of absorption and rate of emission by a small body. 7+7

7\. (a) What is convective mass transfer co-efficient and what are its units ?

(b) Oxygen is diffusing through carbon monoxide with carbon monoxide non-diffusing. The total pressure is 1 atmosphere and temperature is 0°C. The partial pressure of oxygen at two planes 0·2 cm apart is 100 mm and 50 mm of Hg respectively. The diffusivity of mixture is $1{\cdot}85 \times 10^{-5}$ m^2/sec. Calculate the rate of diffusion of oxygen in kg mole/m^2sec through each square cm of two planes. 7+7

8. (a) Define Schmidt number, Sherwood number and Lewis number. What is the physical significance of each ?

(b) Discuss the classification of heat exchangers. Explain the shell and tube type heat exchanger. Why are baffles used ? 7+7