Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 80841

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2021.

Fourth/Sixth/Seventh Semester

Mechanical Engineering

ME 2251/ME 1251/10122 ME 502/080120015/ME 41 — HEAT AND MASS TRANSFER

(Common to Mechanical Engineering (Sandwich)/Mechanical and Automation Engineering)

(Regulations 2008/2010)

(Also Common to PTME 2251 for B.E. (Part-Time) Sixth Semester – Mechanical Engineering – Regulations 2009)

Time : Three hours Maximum : 100 marks

Use of Heat and Mass Transfer Tables permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State Fourier's law of heat conduction.

2. What is lumped system analysis? When is it used?

3. Define velocity boundary layer thickness.

4. Distinguish between laminar and turbulent flow.

5. What is the difference between boiling and condensation?

6. What is meant by compact heat exchanger?

7. Assuming the sun to be a black body emitting radiation with maximum intensity at $\lambda = 0.49$ pm, calculate the surface temperature of the sun.

8. What is irradiation and radiosity?

9. State Pick's law of diffusion.

10. In what case convective mass transfer will happen? Give examples for free and forced convective mass transfer.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Explain the mechanism of heat conduction in solids and gases. (4)

(ii) At a certain instant of time, the temperature distribution in a long cylindrical tube is, $T = 800 + 1000r - 5000r^2$ where, T is in °C and r in m. The inner and outer radii of the tube are respectively 30cm and 50 cm. The tube material has a thermal conductivity of 58 W/m.K and a thermal diffusivity of 0.004 m 2/br. Determine the rate of heat flow at inside and outside surfaces per unit length, rate of heat storage per unit length and rate of change of temperature at inner and outer surfaces. (12)

Or

(b) (i) With neat sketches, explain the different fin profiles. (4)

(ii) Aluminum fins, 1.5 cm long and 1 mm thick are placed on a 2.5 cm diameter tube to dissipate heat. The tube surface temperature is 100°C and the ambient temperature is 25°C. Find the heat loss per fin if the heat transfer coefficient between the fin surface and the ambient is 65 W/m2 .K. Assume k 200 W/nK for aluminum. (12)

12. (a) (i) Explain the velocity boundary layer profile on a flat plate and mentions its significance. (4)

(ii) Engine oil at 26°C is forced Over a 20 cm square plate at a velocity of 1.2 m/s. The plate is heated to a uniform temperature of 60°C. Calculate the heat loss of the plate. (12)

Or

(b) (i) Considering a heated vertical plate in quiescent fluid, draw the Velocity and temperature profile. (4)

(ii) Water at 60°C enters a tube of 2.54 mm diameter at a mean flow velocity of 2 cm/s. Calculate the exit water temperature if the tube is 3 m long and the wall temperature is constant at 80°C. (12)

13. (a) (i) Water at atmospheric pressure is to be boiled in a polished copper pan. The diameter of the pan is 350 mm and is kept at 115°C. Calculate the power of the burner, rate of evaporation in kg/h and the critical heat flux. (8)

(ii) A vertical cooling fin approximating a flat plate 40 cm in height is exposed to saturated steam at atmospheric pressure. The fin is maintained at a temperature of 90°C. Estimate the thickness of the film at the bottom of the fin, overall heat transfer coefficient and heat transfer rate after incorporating McAdams correction. (8)

Or

(b) (i) Explain how heat exchangers are classified? (8)

(ii) A counter flow double pipe heat exchanger using superheated steam is used to heat water at the rate of 10500 kg/h. 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. If U = 814 W/m^{2}°C, calculate the heat transfer area. What would be the increase in area if the fluid flows were parallel? (8)

14. (a) (i) Derive Wien's displacement law of radiation from Planck'g law. (8)

(ii) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C :

(1) Monochromatic emissive power at 1.2 μm length

(2) Wavelength at which the emissive in maximum

(3) Maximum emissive power

(4) Total emissive power. (8)

Or

(b) Two parallel plates of size 1.0 m × 1.0 m spaced 0.5 m apart are located in very large room, the walls are maintained at a temperature of 27°C. One plate is maintained at a temperature of 900°C and the other at 400°C. Their emissivities are 0.2 and 0.5 respectively. If the plates exchange heat between themselves and surroundings find the heat transfer to each plate and to the them. Consider only the plate surfaces facing each other. (16)

15. (a) Air is contained in a tyre tube of surface area 0.5 m2 and wall thickness 10 cm. the pressure of air drops from 2.2 bar to 2.18 bar in a period of 6 days. The solubility of air in the rubber is 0.072 m3 of air per m^{3} of rubber at 1 bar. Determine the diffusivity of air in rubber at operating temperature of 300 K if the volume of air in the tube is 0.028 m^{3}. (16)

Or

(b) Along a horizontal water surface an air stream with velocity $u_{\alpha} = 3$ m/s is flowing. The temperature of the water on the surface is 15°C, the air temperature is 20°C the total pressure is 1 atm (10^{5} N/m^{2}), and the saturation pressure of the water vapour in the air at 20°C is 2337 N/m^{3}. The relative humidity of the air is 33%. The water surface along the wind direction has a length of 10 cm. Calculate the amount of water evaporated per hour per meter from the water surface. The binary diffusivity of water vapour in the air maybe taken as 3.3 × 10^{5} m^{2}/s. The saturation vapour pressure of water at 15°C is 1705 N/m^{2} and kinematic viscosity of the air is 1.5 × 10^{-5} m^{2}/s. (16)

———————