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Question Paper Code : 21562

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2013.

Fourth Semester

Mechanical Engineering

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

(Regulation 2008/2010)

(Common to PTME 2251 – Heat and Mass Transfer for Sixth Semester B.E. (Part-Time) Mechanical Engineering – Regultion 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 fin efficiency and fin effectiveness.
4. Define critical Reynolds number. What is its typical value for flow over a flat plate and flow through a pipe?
5. How does laminar flow differ from turbulent flow?
6. What is burnout point in boiling heat transfer? Why is it called so?
7. Define LMTD of a heat exchanger.
8. What is thermal radiation? What is its wavelength band?
9. Distinguish between irradiation and radiosity.
10. State Fick's law of diffusion.

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 30 cm and 50 cm. The tube material has a thermal conductivity of 58 W/m.K and a thermal diffusivity of 0.004 m^2/hr. 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 $W/m^2.K$. Assume k = 200 W/m.K for aluminum. (12)

12. (a) (i) Discuss briefly the development of velocity boundary layer for flow through a pipe. (4)

(ii) Water at 60°C and a velocity of 2 cm/s flows over a 5 m long flat plate which is maintained at a temperature of 20°C. Determine the total drag force and the rate of heat transfer per unit width of the entire plate. (12)

Or

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

(ii) A horizontal pipe of 6 m length and 8cm diameter passes through a large room in which the air and walls are at 18°C. The pipe outer surface is at 70°C. Find the rate of heat loss from the pipe by natural convection. (12)

13. (a) Discuss briefly the pool boiling regimes of water at atmospheric pressure.

Or

(b) (i) What are the different types of fouling in heat exchangers? (4)

(ii) Hot exhaust gases which enter a cross-flow heat exchanger at 300°C and leave at 100°C are used to heat water at a flow rate of 1 kg/s from 35 to 125°C. The specific heat of the gas is 1000 J/kg.K and the overall heat transfer coefficient based on the gas side surface is 100 W/m^2.K Find the required gas side surface area using the NTU method and LMTD method. (12)

14. (a) (i) State and Prove Kirchhoff's law of thermal radiation. (4)

(ii) What is a black body? A 20 cm diameter spherical ball at 527°C is suspended in the air. The ball closely approximates a black body. Determine the total black body emissive power, and spectral black body emissive power at a wavelength of 3 μm. (12)

Or

(b) An oven is approximated as a long equilateral triangular duct, which has a heated surface maintained at a temperature of 1200 K. The other surface is insulated while the third surface is at 500 K. The duct has a width of a 1 m on a side and the heated and insulated surfaces have an emissivity of 0.8. The emissivity of the third surface is 0.4. For steady state operation find the rate at which energy must be supplied to the heated side per unit length of the duct to maintain its temperature at 1200 K. What is the temperature of the insulated surface?

15. (a) (i) Explain equimolal counter diffusion in gases. (8)

(ii) Discuss briefly the Analogy between heat and mass transfer. (8)

Or

(b) Define mass transfer coefficient. Air at 1 bar pressure and 25°C containing small quantities of iodine flows with a velocity of 5.2 m/s. inside a tube having an inner diameter of 3.05 cm. Find the mass transfer coefficient for iodine transfer from the gas stream to the wall surface. If c_m is the mean concentration of iodine in kg.mol/m^3 in the air stream, find the rate of deposition of iodine on the tube surface by assuming the wall surface is a perfect sink for iodine deposition. Assume $D = 0.0834\ cm^2/s$.