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Reg. No. : .....

Name : .....

Sixth Semester B.Tech. Degree Examination, March 2017

(2008 Scheme)

08.604 : HEAT AND MASS TRANSFER (MU)

Time : 3 Hours Max. Marks : 100

Instructions : *1) Answer **all** questions from Part – **A** and **one full** question from **each** Module of Part – **B**.*
*2) Heat and Mass transfer data book is **permitted**.*

PART – A **(10×4=40 Marks)**

1. Define thermal diffusivity of a substance. Explain its significance in analyzing heat conduction through solids.

2. Discuss about different types of boundary conditions commonly encountered in heat transfer problems.

3. What is conduction shape factor ? Where is it used ?

4. State the scope and application of dimensional analysis in the study of heat transfer. What are the strengths and weakness of dimensional analysis ?

5. What is critical radius of insulation ? Derive the expression for critical radius of insulation on a long hollow cylinder.

6. How do you define the hydrodynamic and thermal boundary layer thickness ? Why accurate knowledge of hydrodynamic and thermal boundary layer thickness is of paramount importance in the study of heat convection ?

7. Define total and monochromatic emissive power of a black body. Sketch the distribution of monochromatic emissive power for the case of a black body, gray body and real surface, all are at the same temperature.

8. Explain Plank's distribution law of thermal radiation. How is it differing from Stefan-Boltzmann law ?

9. Describe the various mechanisms of mass transfer.

10. Discuss the analogy between heat and mass transfer.

P.T.O.

PART – B

Module – I

11. a) Derive the most general form of heat conduction equation in cylindrical coordinates and deduce it for the case of steady one dimensional heat conduction with heat generation in a solid cylinder of constant thermal conductivity. **12**

b) A refrigerant at – 40 °C flows in a copper pipe (k = 400 W/mK) of inside diameter 10 mm and outside diameter 14 mm. A 40 mm thick shell of thermocole (k = 0.03 W/mK) is put on the pipe to reduce losses. Estimate the heat leakage to the refrigerant per meter length of pipe, if the ambient air temperature is 40 °C. Assume the internal and external heat transfer coefficients to be 500 and 5 W/m^2K, respectively. Calculate, also, the amount of refrigerant evaporated per hour taking its latent heat at – 40 °C as 1390 kJ/kg. **8**

12. a) Consider a cylindrical shell with inner and outer surfaces at r_1 and r_2 maintained at uniform temperatures T_1 and T_2, respectively. If there is a uniform heat generation within the shell, obtain expressions for the steady one dimensional radial distribution of the temperature, heat flux and heat rate. **12**

b) Steel balls 12 mm in diameter are annealed by heating to 1150 K and then slowly cooling to 400 K in an air environment. The air temperature is 325 K and airside heat transfer coefficient is 20 W/m^2K. Estimate time required for the cooling process. Use thermo physical properties of stainless steel for solving the problem. **8**

Module – II

13. a) Using dimensional analysis, show for forced convection that Nusselt number is a function of Reynolds number and Prandtl number. **12**

b) Air at a temperature of 27 °C flows with a velocity of 2 m/s over a flat plate of length 30 cm. The plate is heated over its entire length to a temperature of 60°C. Determine :

i) The velocity and thermal boundary layer thickness at the trailing edge.

ii) The local heat flux at the trailing edge and total heat transfer per unit width of the plate. **8**

14. a) With the aid of a neat sketch, explain process of heat exchange in a horizontal cylindrical heat pipe. **10**

b) A pipe (k = 59 W/mK) with an inside diameter of 3.175 cm and wall thickness of 0.318 cm is externally heated by steam at a temperature of 180°C. The water flows through the pipe with a velocity of 1.22 m/s. Calculate the length of the pipe required to heat water from 30°C to 90°C assuming the heat transfer coefficient on the steam side to be 11.3 kW/m^2K. **10**

Module – III

15. a) What are the characteristics of a black body ? What is the principal role of black body behaviour in radiation analysis ? **6**

b) Two black rectangular plates having dimensions 0.5 m × 1m are arranged perpendicular to each other with 1 m side of the rectangles as a common edge. One plate is kept at temperature 1000 K and the other plate at 500 K. The surrounding ambient can be regarded a black body at $T_\infty = 300$ K . Sketch the radiation network, and calculate the heat transfer rate between the plates. **14**

16. a) Derive an expression for isothermal evaporation of water from a surface and its subsequent diffusion through a stagnant air layer above. **10**

b) Air at 35°C and 1 atm flows over a wet flat plate 50 cm long with a velocity of 30 m/s. Calculate the mass transfer coefficient of water vapour in air at the end of the plate. **10**