B.E. / B.Tech. (Mechanical Engineering) Model Curriculum Semester-V

PCCME301 / HEAT1 - Heat Transfer

P. Pages : 3 | GUG/S/25/14068

Time : Three Hours | Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Attempt Q. 1 or Q. 2, Q. 3 or Q. 4, Q. 5 or Q. 6, Q. 7 or Q. 8, Q. 9 or Q. 10.
3. Assume suitable data wherever necessary.
4. Illustrate your answers wherever necessary with the help of neat sketches.
5. Use of Steam Tables, Moiller Chart, Drawing Instruments, Thermodynamic tables for moist air, Heat Transfer data book and non-programmable calculator is permitted.

1. a) Derive the general heat condition equation in cartesian co-ordinate system. **8**

b) A flat wall of a furnace is made up of fire brick, insulating brick and building brick of thicknesses 25 cm, 12.5 cm and 25 cm respectively. The inside wall is at a temperature of 600°C and the atmospheric temperature is 20°C. If the heat transfer coefficient for the outside surface is $10 W/m^2 {}^\circ C$, calculate: **8**

i) That loss per m^2 of wall area:

ii) Temperature of the outside wall surface of the furnace.

Take : $k_{\text{fire brick}} = 1.4 W/m^\circ C$; $k_{\text{insulating brick}} = 0.2 W/m^\circ C$.

OR

2. a) Hot air at a temperature of 60°C is flowing through a steel pipe of 100 mm diameter. The pipe is covered with two layers of different insulating materials of thicknesses 50 mm and 30 mm, and their corresponding thermal conductivities are 0.23 and 0.37 W/m°C. The inside and outside heat transfer coefficients are 58 and 12 $W/m^2 {}^\circ C$. The atmosphere is at 25°C. Find the rate of heat loss from a 50 m length of pipe. Neglect the resistance of steel pipe. **10**

b) Obtain the relation that represents the condition for minimum resistance and consequently maximum heat flow rate of sphere? **6**

3. a) The temperatures on the two surface of a 20 mm thick steel plate (k = 50 W/mºC), having a uniform volumetric heat generation of $40 \times 10^6 W/m^3$, are 160ºC and 100ºC. Neglecting the end effects, determine the following: **8**

i) The position and value of the maximum temperature, and

ii) The flow of heat from each surface of the plate.

b) One end of a long rod, 30 mm in diameter, is inserted into the furnace with the other end projecting in the outside air. After the steady state is reached, the temperature of the rod is measured at two points 150 mm apart and found to be 140°C and 100°C. The atmospheric air temperature is 30°C. If the heat transfer coefficient is $60 W/m^2 {}^\circ C$, determine the thermal conductivity of the rod. **8**

OR

4. a) Obtain the temperature distribution equation in the body/solid for Newtonian heating or cooling? **8**

b) A copper slab $\left(\rho = 9000\,kg/m^3,\ c = 380\,J/kg^\circ C,\ k = 370\,W/m^\circ C\right)$ measuring $400mm \times 400mm \times 5mm$ has a uniform temperature of 250ºC. Its temperature is suddenly lowered to 30ºC. Calculate the time required for the plate to reach the temperature of 90ºC. Assume convective heat transfer coefficient as $90\,W/m^{2\,\circ}C$. **8**

5. a) A plate of length 750 mm and width 250 mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 5 m/s. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stoke, calculate: **8**

i) Boundary layer thickness at the middle of plate,

ii) Shear stress at the middle of plate, and

iii) Friction drag on one side of the plate.

b) Find the convective heat loss from a radiator 0.6 m wide and 1.2 m high maintained at a temperature of 90ºC in a room at 20ºC. Consider the radiator as a vertical plate. **8**

OR

6. a) Explain with boiling curve, various regimes of saturated pool boiling? **8**

b) A vertical plate 500 mm high and maintained at 30°C is exposed to saturated steam at atmospheric pressure. Calculate the following: **8**
i) The rate of heat transfer, and
ii) The condensate rate per hour per meter of the plate width for film condensation.
The properties of water film at the mean temperature are:
$\rho = 980.3\,kg/m^3;\ k = 66.4 \times 10^{-2}\,W/m^\circ C;\ \mu = 434 \times 10^{-6}\,kg/ms$ and $h_{fg} = 2257\,kJ/hg.$
Assume vapour density is small compared to that of the condensate.

7. a) Define the following terms. **4**

i) Total emissive power.

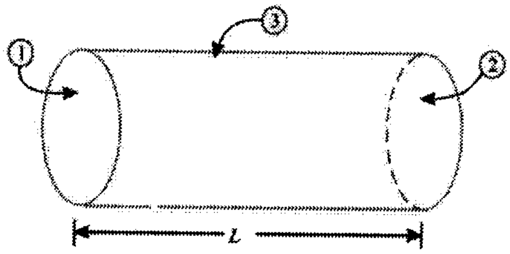
ii) Radiosity.

b) State and prove Kirchoff's law of radiation? **6**

c) What is black body how does it differ from gray body? What are the properties of black body? **6**

OR

8. a) Define shape factor in relation to radiation heat exchange by radiation? The radiation shape factor of a circular surface of a thin hollow cylinder of 10 cm diameter and 10 cm length is 0.15. What is the shape factor of curved surface of the cylinder with respect to itself? **8**



b) Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperatures of 427° C and 27° C respectively. ε (hot plate) = 0.9 and ε (cold plate) = 0.6. If a polished aluminum shield is placed between them, find the percentage reduction in the heat transfer, ε (shield) = 0.4. **8**

9. a) Derive an expression for LMTD in case of counter flow Heat exchangers? **8**

b) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75°C and 20°C respectively. The exit temperature of hot water is 45°C. If the individual heat transfer coefficients on both sides are $650\ \mathrm{W/m^2 {}^\circ C}$, calculate the area of the heat exchanger. **8**

OR

10. a) Write a note on compact heat exchanger? **6**

b) Oil $\left(c_p = 3.6\,\mathrm{kJ/kg^\circ C}\right)$ at 100ºC flows at the rate of 30000 kg/h and enters into a parallel flow heat exchanger. Cooling water $\left(c_p = 4.2\,\mathrm{kJ/kg^\circ C}\right)$ enters the heat exchanger at 10ºC at the rate of 50000 kg/h. The heat transfer area is $10\mathrm{m}^2$ and $U = 1000\,\mathrm{W/m^2 {}^\circ C}$. Calculate the following. **10**

i) The outlet temperature of oil, and water.

ii) The maximum possible outlet temperature of water.

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