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

PCCME301 - Heat Transfer

P. Pages : 3 **GUG/W/24/14068**

Time : Three Hours * 5 5 8 5 * Max. Marks : 80

Notes :
1. All questions carry equal marks.
2. Assume suitable data wherever necessary.
3. Illustrate your answers wherever necessary with the help of neat sketches.
4. Use of Steam tables, Mollier's chart, Drawing instruments, Thermodynamic tables for moist air, Heat Transfer data book & non-programmable calculator is permitted.
5. 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.

1. a) State Fourier's Law of Heat Conduction? Derive expression for temperature distribution under 1-dimensional steady state heat conduction for plane wall? **8**

b) Calculate the rate of heat flow through the wall of a refrigerated van of 1.5 mm of steel sheet at outer surface. 100 mm plywood at the inner surface and 2 cm of glass-wool in between, if the temperatures of the inside and outside surfaces are- 15ºC and 24ºC respectively. Take thermal conductivities of steel, glass-wool and plywood as 23.2 W/mºC, 0.014 W/mºC and 0.052 W/mºC respectively. **8**

OR

2. a) Define critical thickness of insulation and obtain the condition for critical thickness of radius in case of sphere? **8**

b) A wire of 6.5 mm diameter at a temperature of 60ºC is to be insulated by a material having k = 0.174 W/mºC. Convection heat transfer coefficient $(h_0) = 8.722\,W/m^{2o}C$. The ambient temperature is 20ºC. For maximum heat loss, what is the minimum thickness of insulation and heat loss per metre length? Also find percentage increase in the heat dissipation too. **8**

3. a) A plane wall 80 mm thick (k = 0.15 W/mºC) is insulated on one side while the other side is exposed to environment at 90ºC. The rate of heat generation within the wall is $12\times10^4\,W/m^3$. If the convective heat transfer coefficient between the wall and the environment is $560\,W/m^{2o}C$, determine the maximum temperature to which the wall will be subjected. **8**

b) It is required to heat oil to about 350ºC for frying purpose. A laddel is used in the frying. The section of the handle is $4\,mm\times15\,mm$. The surroundings are at 35ºC. The conductivity of the material is 210 W/mºC. If the temperature at a distance of 400 mm from the oil should not reach 45ºC, determine the convective heat transfer coefficient. **8**

OR

4. a) The temperature of the air stream in a tube is measured with the help of a thermometer placed into a protective well filled with oil. The thermometer well is made of a steel tube (k = 55.8 W/mºC), 120 mm long and 1.5 mm thick. The surface heat transfer coefficient from the air to the protective well is $23.3\,W/m^{2o}C$ and the temperature recorded by the thermometer is 84ºC. If the temperature at the base of the well is 40ºC, what is the measurement error? **8**

b) A sphere of 200 mm diameter made of cast iron initially at uniform temperature of 400ºC is quenched into oil. The oil bath temperature is 40ºC. If the temperature of sphere is 100ºC after 5 minutes, find heat transfer coefficient on the surface of the sphere. **8**

Take: $C_P(\text{cast iron}) = 0.32\,kJ/kg^oC$; $\rho(\text{cast iron}) = 7000\,kg/m^3$

5. a) Air at 20ºC is flowing over a flat plate which is 200 mm wide and 500 mm long. The plate is maintained at 100ºC. Find the heat loss per hour from the plate if the air is flowing parallel to 500 mm side with 2 m/s velocity. What will be the effect on heat transfer if the flow is parallel to 200 mm side. **8**

b) A vertical cylinder 1.5 m high and 200 mm in diameter is maintained at 90ºC in an atmosphere environment of 30ºC. Calculate the heat loss by free convection from the surface of the cylinder? **8**

OR

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

b) A vertical plate 450 mm high and maintained at 30ºC is exposed to saturated steam at atmospheric pressure. Calculate: **8**

i) The rate of heat transfer, and

ii) The condensate rate per hour per metre for plate width film condensation.

The properties of water film at the mean temperature are:

$\rho = 980.3\,kg/m^3$; $k = 66.4\times10^{-3}\,W/m^oC$; $\mu = 434\times10^{-6}\,kg/ms$; and
$h_{fg} = 2256.9\,kJ/kg$

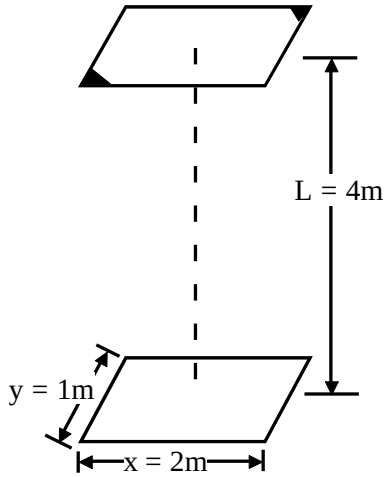
7. a) State and prove Kirchhoff's law of radiation? **6**

b) State and explain Wien's displacement law? **6**

c) What is black body? How does it differ from gray body. **4**

OR

8. a) Two parallel rectangular surfaces $1\text{m} \times 2\text{m}$ are opposite to each other at a distance of 4 m. The surfaces are black and at 100ºC and 200ºC. Calculate the heat exchange by radiation between the two surfaces. **8**



b) Consider two large parallel plates, one at 1000 K with emissivity 0.8 and other is at 300 K having emissivity 0.6. A radiation shield is placed between them. The shield has emissivity as 0.1 on the side facing hot plate and 0.3 on the side facing cold plate. Calculate percentage reduction in radiation heat transfer as a result of radiation shield. **8**

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

b) The flow rates of hot and cold water streams running through a heat exchanger are 600 kg/h and 1500 kg/h respectively. The inlet temperatures on the hot and cold sides are 70ºC and 25ºC respectively. The exit temperature of hot water is 50ºC. If the individual heat transfer coefficients on both sides are $700\,\text{W/m}^2\text{°C}$, calculate the area of the heat exchanger. **8**

OR

10. a) Derive the expression for effectiveness by NTU method for parallel flow heat exchanger? **8**

b) Two fluids, A and B exchange heat in a counter-current heat exchanger. Fluid A enters at 420ºC and has a mass flow rate of 1 kg/s. Fluid B enters at 20ºC and has a mass flow rate of 1 kg/s. Effectiveness of heat exchanger is 75%. **8**

Determine:

i) The heat transfer rate;

ii) The exit temperature of fluid B.

Specific heat of fluid A is 1 kJ/kg K and that of fluid B is 4 kJ/kg K.

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