Total No. of Questions : 10]

SEAT No. :

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T.E. (Mechanical) (Common to Mech. S/W, Automobile)

HEAT TRANSFER

(2012 Course) (302042) (End Semester) (Semester - I)

Time : 2½ Hours] *[Max. Marks : 70*

Instructions to the candidates:

1) *Assume suitable data if necessary.*
2) *Figures to the right indicate full marks.*
3) *Use of Scientific calculator is allowed.*

Q1) a) Derive three dimensional general heat conduction equation in Cartesian coordinates for anisotropic material for unsteady state condition with uniform internal heat generation. **[7]**

b) What is unsteady state? Define internal temperature gradient. When can it be neglected? **[3]**

OR

Q2) a) Write a note on temperature boundary condition and heat flux boundary condition. **[4]**

b) A long hollow cylinder has inner and outer radii as 10cm and 20cm respectively. The rate of heat generation is 1 kW/m^3, the thermal conductivity of cylinder material is 0.2 W/mk. If the maximum temperature occurs at radius of 15cm and temperature of Outer surface is 60ºC, find temperature at the inner surface of the cylinder. **[6]**

Q3) a) Explain critical radius of insulation. **[4]**

b) A 5cm diameter steel ball, initially at a uniform temp of 450ºC is suddenly placed in an environment at 100ºC with h = 10 W/m^{2}K. Steel properties: Cp = 460 J/kgK, density = 7800 kg/m^3, K = 35 W/mK. Calculate the time required for the ball to attain a temperature of 150ºC. **[6]**

OR

Q4) a) Write a note on Overall heat transfer coefficient. **[4]**

b) A cylindrical metal rod of 5 cm diameter and 20 cm long with thermal conductivity 225 W/mK protrudes in atmosphere at 30°C. It projects from furnace wall at 300°C. A convective heat transfer coefficient of air is 10 W/m^2K. Determine temperature at the free end of the rod assuming it as a fin insulated at end. **[6]**

Q5) a) Explain physical significance of any four dimensionless numbers used in convection. **[8]**

b) Water flows at the rate of 360kg/hr through a metallic tube of 10mm diameter and 3m length. It enters the tube at 25°C. Outer surface of the tube is maintained at a constant temperature of 100°C. Calculate the exit temperature of the water. **[8]**

Properties of water:

$\mu = 5.62 \times 10^{-4}$ kg/ms; $C_p = 4174$J/kgK; K = 0.664W/mK.

Use the following correlation:

$N_u = 0.023 Re^{0.8} Pr^{0.4}$ for turbulent flow

$N_u = 3.66$ for laminar flow

OR

Q6) a) Write a note on velocity boundary layer and thermal boundary layer. **[6]**

b) Explain mechanism of natural convection. Distinguish it from forced convection. **[4]**

c) A rectangular plate of length 7cm and width 4cm maintained is at 115°C. It is exposed to still air at 25°C on both sides. Calculate convective heat transfer rate if smaller side of the plate is held vertical. **[6]**

Use Correlation $N_u = 0.59\ (Gr.Pr)^{0.25}$

For air at 70°C, K = 0.03 W/mK; Pr = 0.697; kinematic viscosity $v = 2.076 \times 10^{-6}\ m^2/s$.

Q7) a) State and explain following laws of radiation: **[10]**

i) Planck's Law

ii) Wein's Law

iii) Lambert's cosine rule

iv) Kirchoff's Law

v) Stefan Boltzmann Law

b) Two large parallel steel plates of emissivities 0.8 and 0.4 are held at temperatures 1100 K & 500 K respectively. If a thin radiation shield of emissivity 0.09 is introduced between two plates, determine radiation heat exchange in W/m^2 with and without radiation shield. **[6]**

Use $\sigma = 5.67 \times 10^{-8}\ W/m^2\ K^4$.

OR

Q8) a) What is shape factor? What is shape factor for a plane surface and convex surface with respect to itself? **[10]**

Find the shape factor of following with respect to itself:

i) Cylindrical cavity of diameter D and depth H,

ii) Hemispherical cavity of diameter D,

iii) Conical hole of diameter D and depth H

b) Consider two concentric spheres 'A' and 'B' with diameter of 200mm and 300mm respectively. Space in between these two spheres is evacuated. Liquid air at -153ºC is stored inside sphere 'A'. The surfaces of spheres 'A' and 'B' facing each other are coated with aluminium foil ($\varepsilon = 0.03$). Latent heat of vaporization of liquid air is 209.35 kJ/kg. If the system is kept in a room where ambient temperature is 30ºC,

Calculate the rate of evaporation of liquid air. **[6]**

Q9) a) What is the significance of critical heat flux in design of evaporators? Explain different regimes in pool boiling curve with neat sketch. **[10]**

b) What is LMTD for a heat exchanger? Derive an expression for LMTD of parallel flow heat exchanger. **[8]**

OR

Q10) a) Explain dropwise condensation and filmwise condensation. compare these two. **[6]**

b) A parallel flow heat exchanger is to be designed to cool oil (C_p = 2.1 kJ/kgK, 20 kg/min) from 70°C to 40°C by using cold water (C_p = 4.2 kJ/kg K, 50 kg/min), available at 30°C. The overall transfer coefficient is 133 W/m^2K. Find the area of heat exchanger, outlet temperature of water and effectiveness. **[8]**

c) Explain effectiveness and NTU for a heat exchanger. **[4]**