

Total No. of Questions : 10]

SEAT No. :

P2840**[4958]-1013**

[Total No. of Pages : 4

**T.E.(Mechanical)
HEAT TRANSFER****(2012 Course) (Semester-I) (302042)(End Semester)***Time :2½Hours]**[Max. Marks : 70**Instructions to the candidates:*

- 1) *Solve 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.*
- 2) *Draw neat diagrams wherever necessary.*
- 3) *Use of scientific calculator is allowed.*
- 4) *Assume suitable data wherever necessary.*
- 5) *Figures to the right indicate full marks.*

Q1) a) Derive an expression for critical radius of insulation of sphere. [6]

- b) A 2 kW resistance heater wire whose thermal conductivity is 15 W/m. °C has a diameter of 4 mm and length of 0.5 m. It is used for boiling water. If the outer surface temperature of wire is 105 °C, determine the temperature at the centre of the wire. [4]

OR

Q2) a) Prove that $\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\left(\frac{hA_s}{\rho VC_p}\right)t\right]$ with usual notations. [6]

- b) Explain the concept of Thermal Resistance. [4]

Q3) a) What is response and time constant of a thermocouple? [4]

- b) The temperature distribution across a wall of 1 m thick at a certain instant of time is given as $T(x)=a+bx+cx^2$ where T is in degrees Celsius and x is in meters, while $a = 800$ °C, $b = -350$ °C/m, and $c = -60$ °C/m². A uniform heat generation, $= 1000$ W/m³, is present in the wall of area 10m² having the properties $= 1600$ kg/m³, $k=40$ W/m.K, and $c_p = 4$ kJ/kg.K. Determine:[6]

- i) the rate of heat transfer entering the wall ($x=0$) and leaving the wall ($x = 1$ m)
- ii) the rate of change of energy storage in the wall.

OR

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Q4) a) Derive the three dimensional heat diffusion equation in Cartesian co-ordinates from first principles. [6]

b) Calculate the temperature at the tip of fin of a 3 mm diameter, 3 cm long fin if fin is made up of [4]

i) Copper ($k=350 \text{ W/m.K}$) and

ii) Teflon ($k=0.35 \text{ W/m.K}$)

Take temperature at the fin base = 120°C , ambient temperature = 20°C
 $h=10 \text{ W/m}^2.\text{K}$

Q5) a) Define and give the significance of following dimensionless numbers used in Natural Convection. [6]

i) Prandtl Number,

ii) Grashof Number

b) Explain: Local and Average heat transfer coefficient. [5]

c) Consider a $0.6\text{-m} \times 0.6\text{-m}$ thin square plate in a room at 30°C . One side of the plate is maintained at a temperature of 90°C , while the other side is insulated. Determine the rate of heat transfer from the plate by natural convection if the plate is vertical.

Use following correlation.

$$\text{Nu} = 0.59 \text{ Ra}L^{1/4}$$

Properties of air at 60°C : $k = 0.02808 \text{ W/m.K}$, $\text{Pr} = 0.7202$,

$$\nu = 1.896 \times 10^{-5} \text{ m}^2/\text{s} \quad [6]$$

OR

Q6) a) Differentiate : Natural convection and Forced convection. [5]

b) Explain concept of velocity and thermal boundary layer. [6]

c) A 25-cm-diameter stainless steel ball ($\rho=8055 \text{ kg/m}^3$, $c_p = 480 \text{ J/kg.K}$) is removed from the oven at a uniform temperature of 300°C . The ball is then subjected to the flow of air at 1 atm pressure and 25°C with a velocity of 3 m/s . The surface temperature of the ball eventually drops to 200°C . Determine the average convection heat transfer coefficient during this cooling process and estimate how long the process will take.

$$\text{Nu} = 2 + [0.4 \times \text{Re}^{1/2} + 0.06 \times \text{Re}^{2/3}] \text{Pr}^{0.4} (\mu_\infty / \mu_s)^{1/4}$$

The properties of air at the free-stream temperature of 25°C and 1 atm:

$$k = 0.02551 \text{ W/m.K}, \nu = 1.562 \times 10^{-5} \text{ m}^2/\text{s}, \mu = 1.849 \times 10^{-5} \text{ kg/m.s} \text{ Pr} = 0.7296$$

$$\text{Take } \mu_s = 2.76 \times 10^{-5} \text{ kg/m.s} \quad [6]$$

- Q10)** a) Derive an expression for effectiveness of parallel flow heat exchanger. [7]
- b) Compare: Film wise and drop wise condensation. [4]
- c) Cold water enters a counter-flow heat exchanger at 10°C at a rate of 8 kg/s, where it is heated by a hot-water stream that enters the heat exchanger at 70°C at a rate of 2kg/s, Assuming the specific heat of water to remain constant at $C_p=4.18\text{kJ/kg.K}$, determine the maximum heat transfer rate and the outlet temperatures of the cold-and the hot-water streams for this limiting case. [6]



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