Total No. of Questions : 10]

SEAT No. :

P2840

[Total No. of Pages : 4

[4958]-1013
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 $\frac{\theta}{\theta_i} = \frac{T - T_\infty}{T_i - T_\infty} = \exp\left[-\left(\frac{hA_S}{\rho VCp}\right)t\right]$ 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 Celsuis and x is in meters, while a =800 °C,b = -350 °C/m, and c=-60 °C/m^2. A uniform heat generation, = 1000 W/m^3, is present in the wall of area 10m^2 having the properties = 1600kg/m^3, k=40 W/m.K,and c_p=4kJ/kg.K. Determine:**[6]**

i) the rate of heat transfer entering the wall (x=0) and leaving the wall (x = 1m)

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 W/m.K) and

ii) Teflon (k=0.35W/mK)

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

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-m 3 0.6-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.

$Nu= 0.59\ RaL^{1/4}$

Properties of air at 60°C: k = 0.02808 W/m.K, Pr = 0.7202,

$v = 1.896\times10^{-5}\ m^2/s$ **[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 (ρ=8055 kg/m^3, c_p= 480J/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 1atm pressure and 25°C with a velocity of 3m/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.

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

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

$k = 0.02551\ W/m.K, v =1.562\times10^{-5} m^2/s, \mu=1.849\times10^{-5} kg/m.s\ Pr=0.7296$

Take $\mu_s= 2.76\times10^{-5}$kg/m.s **[6]**

Q7) a) Write a note on radiation shields. **[4]**

b) Write the statements and mathematical expressions of the following laws in radiation heat transfer: **[6]**

i) Planck's law ii) Wien's law

c) Consider a 20- cm- diameter spherical ball at 800 k suspended in air. Assuming the ball closely approximates a blackbody, determine **[6]**

i) the total blackbody emissive power,

ii) the total amount of radiation emitted by the ball in 5 min.

iii) the spectral blackbody emissive power at a wavelength of 3mm.

Take $C_1 = 3.74177\times10^8$ W. $\mu m^4/m^2$, $C_1 = 1.43878\times 10^4$ μm.K

OR

Q8) a) What is a gray body? How does it differ from a black body? **[4]**

b) Write the statements and mathematical expressions of the following laws in radiation heat tranfer: **[6]**

i) Kirchhoff's law ii) Lambert's law

c) A thermocouple used to measure the temperature of hot air flowing in a duct whose walls are maintained at 400 K shows a temperature reading of 650 K. Assuming the emissivity of the thermocouple junction to be 0.6 and the convection heat transfer coefficient as 80 $W/m^2.°C$, determine the actual temperature of the air. **[4]**

d) Define: Radiosity **[2]**

Q9) a) Derive an expression for LMTD of counter flow heat exchanger. **[6]**

b) Explain working of a heat pipe with neat sketch. **[6]**

c) A counter-flow double -pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 $W/m^2.K$, determine the length of the heat exchanger required to achieve the desired heating. **[5]**

OR

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 Cp=4.18kJ/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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