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5E3176

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5E3176
B.Tech. V Sem.(Main/Back) Exam. Dec. 2012
Mechanical Engg.
5ME2 Heat Transfer

Time : 3 Hours **Maximum Marks : 80**

Min. Passing Marks : 24

Instructions to Candidates:

*Attempt any **five question** selecting **one question** from **each unit** . All Questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used / calculated must be stated clearly.*

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. **Nil** 2. **Nil** .

UNIT-I

Q.1 (a) What is thermal contact resistance ? How it is related to thermal contact conductance? 6

ii) What is the importance of thermal diffusivity?

iii) What is the physical mechanism of heat conduction in a solid, a liquid, and a gas?

(b) Consider a 0.8m high and 1.5 m wide double-pane window consisting of two 4-mm thick layers of glass (k=0.78 W/m.K) separated by a 10mm wide stagnant air space (k=0.026 W/m.K). Determine the steady rate of heat transfer through this double pane window and the temperature of its inner surface for a day during which the room is maintained at 20°C while the temperrature of the outdoors is -10°C. Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be h_1=10 W/m^2.°c and h_2=40 W/m^2.°c, which includes the effects of radiation. 10

OR

(a) (i) What is the critical radius of nsulation? How is it defined for a cylindri cal layer?

(ii) What does the thermal resistance of a medium represent ?

(iii) Consider heat conduction through a wall of thickness L and area A. Under what conditions will the temperature distributions in the wall be a straight line? 6

(b) An 8 cm. thick plane wall generates heat at the rate of 1.2×10^5 W/m^3. One side of the wall is exposd to environment at 90°c whilst the other side is insulated. The convective heat transfer coefficient between the wall and environment is 560 W/m^2-deg. Proceed from the basic principles to determine the maximum temperaure to which the wall will be subjected. The thermal conductivity of the wall material may be taken as 0.15 W/m-deg. 10

UNIT-II

2. (a) For a constant cross-section area fin, obtain the temperature distribution and total heat flow rate under steady state conditions when one end of the fin is attached to a body at high temperature and other end of the fin is insulated. 8

(b) An egg with mean diameter of 4cm and initially at 25°c is placed in a boiling water pan for 4 minutes and found to be boiled to the consumer taste. For how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5°c? Use lumped parameter theory and presume the fol -lowing properties for egg :

$k = 12$ W/m-deg , $h = 125$ W/m^{2}deg , $c = 2$ kJ/kgk and $\rho = 1250$ kg/m^3 8

OR

(a) Explain the esseutial features of Blasius method of solving laminar boundary layer equations for a flat plate. Derive expression for boundary layer thickness from this solution. 8

(b) Air at 2bar and 40°c is heated as it flows through 30mm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at 100°c all along the lenght of tube, make calculations for the heat transfer per unit lenght of the tube. Proceed to calculate the increase in bulk temperature

over one meter lenght of the tube. Use the following correlation $Nu = 0.023\ (Re)^{0.8}\ (Pr)^{0.4}$ and take the following thermo-physical properties of air at the average film temperature of 70°C.

$\mu = 20.6 \times 10^{-6}$ Ns/m^2, Cp = 1.009 kJ/kg-deg

k= 0.0297 W/m-deg, and Pr =0.694

UNIT-III

Q3. (a) Define and explain the physical significance of -

(1) Stanton Number (2) Grashof Number

(3) Prandtl Number (4) Nusselt Number. 8

(b) Calculate the rate of heat loss from a human body which may be cosidered as a vertical cylinder 30 cm in diameter and 175 cm. high in still air at 15°c. The skin temperature is 35°c and emissivity at the skin surface is 0.4.Nglect sweating and effect of clothing. Thermo-physical properties of air at 25°c are :

$\nu = 15.53 \times 10^{-6}$ m^2/s , k= 0.0263 W/m-deg , Pr = 0.7

$\beta = 0.00335$ per degree kelvin. Use the relation $Nu = 0.13\ (Gr \times Pr)^{0.33}$

8

OR

(a) Discuss in detail the various regimes in boiling and explain the condition for the growth of bubbles. What is the effect of bubble size on boiling? 8

(b) How does filmwise condensation differ from dropwise condensation? Analyse film condensation on a flat vertical plate by considering shear, gravity and vapour forces acting on the condensate layer. Determine an expression for the condensate velocity and the mass flow rate. 8

UNIT-IV

Q4. (a) What is the heat capacity rate ? What can you say about the temperature changes of the hot and cold fluids in a heat exchanger if both fluids have the same capacity rate? What does a heat capacity of infinity for a fluid in a heat exchanger mean? 4

(b) Can the logarithmic mean temperature difference ΔT_{lm} of a heat ex changer be a negative quantity ? Explain. 4

(c) Derive the relationship between the effectiveness and the number of trans--fer units for counter flow heat exchangers. 8

OR

(a) A counterflow heat exchanger is used to cool 2000 kg/hr of oil (Cp =2.5kJ/ kg K) from 105°c to 30°c by the use of water entering at 15°c. If the overall heat transfer coefficient is expected to be 1.5 kW/m²K, make calculations for the water flow rate, the surface area required and the effectiveness of heat exchanger. Presume that the exit temperature of the water is not to exceed 80°c. Use NTU-effectiveness approach. 12

(b) Under what conditions can a counterflow heat exchanger have an effective-ness of one? What would your answer be for a parallel flow heat exchanger ? 4

UNIT-V

Q5. (a) What is a graybody? How does it differ from a blackbody? What is a diffuse gray surface ? 4

(b) Derive a general relation for the radiation shape factor in case of radiation between two surfaces. 12

OR

(a) A thin shield of emissivity ϵ_s (on both sides) is placed between two infinite paralled plates of emissivities ϵ_1 and ϵ_2, and temperature T_1 and repectiv-ly. If $\epsilon_1=\epsilon_2=\epsilon_s$, show that temperature of the shield is given by 8

$$\left(\frac{T_1^4+T_2^4}{2}\right)^{3/4}$$

(b) Consider a hemispherical furnace with a flat circular base of diameter D. Determine the view factor from the dome of this furnace to its base. 8
