

5E3176

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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. Nil2. 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 ( $k=0.78 \text{ W/m.K}$ ) separated by a 10mm wide stagnant air space ( $k=0.026 \text{ W/m.K}$ ). 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  $20^\circ\text{C}$  while the temperature of the outdoors is  $-10^\circ\text{C}$ . Take the convection heat transfer coefficients on the inner and outer surfaces of the window to be  $h_1=10 \text{ W/m}^2\cdot^\circ\text{C}$  and  $h_2=40 \text{ W/m}^2\cdot^\circ\text{C}$ , which includes the effects of radiation.

10

## OR

- (a) (i) What is the critical radius of insulation? How is it defined for a cylindrical 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  $1.2 \times 10^5 \text{ W/m}^3$ . One side of the wall is exposed to environment at  $90^\circ\text{C}$  whilst the other side is insulated. The convective heat transfer coefficient between the wall and environment is  $560 \text{ W/m}^2\text{-deg}$ . Proceed from the basic principles to determine the maximum temperature to which the wall will be subjected. The thermal conductivity of the wall material may be taken as  $0.15 \text{ W/m-deg}$ . 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  $25^\circ\text{C}$  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  $5^\circ\text{C}$ ? Use lumped parameter theory and presume the following properties for egg :
- $k = 12 \text{ W/m-deg}$  ,  $h = 125 \text{ W/m}^2\text{deg}$  ,  $c = 2 \text{ kJ/kgk}$  and  $\rho = 1250 \text{ kg/m}^3$  8

## OR

- (a) Explain the essential 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  $40^\circ\text{C}$  is heated as it flows through 30mm diameter tube at a velocity of 10 m/s. If the wall temperature is maintained at  $100^\circ\text{C}$  all along the length of tube, make calculations for the heat transfer per unit length of the tube. Proceed to calculate the increase in bulk temperature



over one meter length 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  $70^{\circ}C$ .

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

$$k = 0.0297 \text{ W/m-deg, and } Pr = 0.694$$

### UNIT-III

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

(1) Stanton Number                      (2) Grashof Number

(3) Prandtl Number                      (4) Nusselt Number.

(b) Calculate the rate of heat loss from a human body which may be considered as a vertical cylinder 30 cm in diameter and 175 cm. high in still air at  $15^{\circ}C$ . The skin temperature is  $35^{\circ}C$  and emissivity at the skin surface is 0.4. Neglect sweating and effect of clothing. Thermo-physical properties of air at  $25^{\circ}C$  are :

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

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

### 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?

(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.

### 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?

- (b) Can the logarithmic mean temperature difference  $\Delta T_{lm}$  of a heat exchanger be a negative quantity? Explain. 4
- (c) Derive the relationship between the effectiveness and the number of transfer units for counter flow heat exchangers. 8

**OR**

- (a) A counterflow heat exchanger is used to cool 2000 kg/hr of oil ( $C_p = 2.5 \text{ kJ/kg K}$ ) from  $105^\circ\text{C}$  to  $30^\circ\text{C}$  by the use of water entering at  $15^\circ\text{C}$ . If the overall heat transfer coefficient is expected to be  $1.5 \text{ kW/m}^2\text{K}$ , 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  $80^\circ\text{C}$ . Use NTU-effectiveness approach. 12
- (b) Under what conditions can a counterflow heat exchanger have an effectiveness 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  $\epsilon_s$  (on both sides) is placed between two infinite parallel plates of emissivities  $\epsilon_1$  and  $\epsilon_2$ , and temperature  $T_1$  and respectively. If  $\epsilon_1 = \epsilon_2 = \epsilon_s$ , show that temperature of the shield is given by

$$\left( \frac{T_1^4 + T_2^4}{2} \right)^{3/4} \quad 8$$

- (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