



May - June - 2011

[3963] - 212

**T.E. (Mechanical) (Semester - I) Examination, 2011**  
**HEAT TRANSFER**  
**(2008 Pattern) (New)**

Time : 3 Hours

Max. Marks : 100

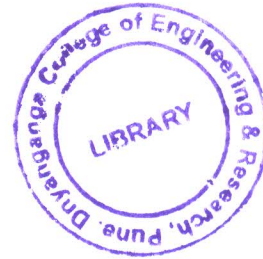
- Instructions :** 1) Answer 3 questions from Section I and 3 questions from Section II.  
2) Answers to the two Sections should be written in separate books.  
3) Neat diagrams must be drawn wherever necessary.  
4) Black figures to the right indicate full marks.  
5) Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.  
6) Assume suitable data, if necessary.

**SECTION - I**

**Unit - I**

1. a) Identify the mode(s) of heat transfer in the following :

- Heat transfer from a room heater
- Hot plate exposed to atmosphere
- Heat loss from thermos flask
- Coding of Aactiva scooter engine
- Heat loss from automobile radiator
- Heat transfer of sun energy to your classroom.



b) A steel pipe ( $K = 50 \text{ W/mK}$ ) of ID 100 mm and OD 110 mm is to be covered with two layers of insulations, each having a thickness of 50 mm. The thermal conductivity of first insulation is  $0.06 \text{ W/m}^\circ\text{C}$  and that of the second is  $0.12 \text{ W/mK}$ . Calculate the loss of heat per meter length of pipe and the interface temperature between the two layers of insulations, when the temperature of the inside tube surface is  $250^\circ\text{C}$  and that of the outside surface of the insulation is  $50^\circ\text{C}$ .

If the order of insulations is reversed, find the change in heat loss and comment on the result from insulation point of view.

OR

2. a) Derive the expression for Logarithmic Mean Area (LMA) for hollow cylinder as;

$$A_m = \frac{A_o - A_i}{\ln(A_o / A_i)} ; \text{ where } A_m \text{ is LMA, } A_o \text{ outer surface area and } A_i \text{ inner}$$

surface area of the cylinder.

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- b) Calculate the rate of heat loss for a red brick wall of length 5 m, height 4 m and thickness 25 cm. Temperature of the inner surface is  $110^{\circ}\text{C}$  and that of the outer surface is  $40^{\circ}\text{C}$ . Thermal conductivity of the red brick is  $0.7 \text{ W/mK}$ . Also, calculate the temperature at an interior point of the wall (in the thickness), 20 cm away from the inner surface of the wall.

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### Unit – II

3. a) Prove that critical radius of insulation for cylinder is  $k/h$  and that for sphere is  $2k/h$ ; where  $k$  is conductivity of insulation and  $h$  is heat transfer coefficient between insulation and surroundings. Use standard notations.
- b) A hollow sphere of inside radius 30 mm and outside radius 50 mm is electrically heated at its inner surface at a constant rate of  $10^5 \text{ W/m}^2$ . The outer surface is exposed to a fluid at  $30^{\circ}\text{C}$  with heat transfer coefficient of  $170 \text{ W/m}^2\text{K}$ . Thermal conductivity of the sphere material is  $20 \text{ W/mK}$ . Calculate the inner and outer surface temperatures.

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OR

4. a) The inside and outside surfaces of a hollow sphere  $a \leq r \leq b$  at  $r = a$  and  $r = b$  are maintained at temperatures  $T_1$  and  $T_2$  respectively. The thermal conductivity of the sphere material varies with temperature as :

$k(T) = k_0(1 + \alpha T + \beta T^2)$ . Prove that the total heat flow rate  $Q$ , through the sphere is given as :

$$Q = \frac{4\pi k_0 ab}{(b-a)} (T_1 - T_2) \left[ 1 + \frac{\alpha}{2}(T_1 + T_2) + \frac{\beta}{3}(T_1^2 + T_1 T_2 + T_2^2) \right].$$

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- b) Nichrome wire, having a resistivity of  $100 \mu\Omega - \text{cm}$ , is to be used as a heating element in a 10 kW heater. The wire surface temperature should not exceed  $1220^{\circ}\text{C}$ . Take surrounding air temperature as  $20^{\circ}\text{C}$ . Convective heat transfer coefficient on  $1.15 \text{ kW/m}^2\text{K}$  and thermal conductivity of Nichrome as  $17 \text{ W/mK}$ . Find out what diameter of Nichrome wire is necessary for 1 m long heater.

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### Unit – III

5. a) Derive the expressions for heat transfer rate  $Q$  and temperature distribution for a short fin using standard notations.
- b) In an experiment to determine the thermal conductivity of a very long solid rod of 2.5 cm diameter, its one end is placed in a furnace and rod is projecting into a room with ambient air at  $22^{\circ}\text{C}$ . After steady-state conditions are achieved, the temperatures at two points 10 cm apart, are found to be  $110^{\circ}\text{C}$  and  $85^{\circ}\text{C}$  respectively. Convective heat transfer coefficient between the rod surface and the surrounding air is  $28.4 \text{ W/m}^2\text{K}$ . Determine the thermal conductivity of the rod material.

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OR

