B.Tech Sem – V (2007 Course) (Mechanical Engg.) : SUMMER - 2019
SUBJECT: HEAT TRANSFER

Day: Monday
Date: 13/05/2019

S-2019-3084

Time: 10.00 AM TO 01.00 PM
Max. Marks: 80

N.B.:

1) **Q. 1** and **Q. 5** are **COMPULSORY** and attempt **ANY TWO** questions from the remaining questions in both the sections.
2) Answer to both sections should be written in SAME answer books.
3) Figures to the right indicate **FULL** marks.
4) Assume suitable data wherever **necessary**.
5) Use non –programmable **CALCULATOR** is allowed.

SECTION - I

Q.1 **a)** What is Fourier's law of heat conduction? What are the assumptions made? **(04)**

b) What is critical thickness of insulation? **(05)**

c) What is thermo-well? Explain its working with the help of a neat sketch. **(05)**

Q.2 **a)** Derive an expression for general heat conduction equation in Cartesian coordinates. **(08)**
Reduce the equation to Fourier's equation, Laplace equation and Poisson's equation.

b) An exterior wall of a house may be approximated by a 0.1 m layer of common brick (k = 0.7 W/m°C), followed by a 0.04 m layer of gypsum plaster (k = 0.48 W/m°C). What thickness of loosely pack rock wool insulation (k = 0.065 W/m°C) should be added to reduce the heat loss or gain through the wall by 80%? **(05)**

Q.3 **a)** A long hollow cylinder has inner and outer radii 50 mm and 150 mm respectively. It generated heat at a rate of 1 kW/m^3 (k = 0.5 W/m°C). If the maximum temperature occurs at radius of 100 mm, and temperature of outer surface is 50 °C. **(08)**
Find
i) Temperature at inner surface, ii) Maximum temperature in the cylinder.

b) For a particular material if thermal conductivity behaves according to the relation, $k = k_0(1 + \beta T)$ at different values of β, show variation in temperature profile when heat flows through a plane slab. **(05)**

Q.4 **a)** Define efficiency and effectiveness of fins. Derive relations for efficiency and effectiveness of different cases of a rectangular fin with uniform cross-section. **(08)**

b) An egg with mean diameter 40 mm and initially at 20 °C is placed in boiling water pan for 4 minutes and found to be boiled to the consumer's taste. For how long should a similar egg for same consumer be boiled when taken from a refrigerator at 5 °C? **(05)**
Take following properties for an egg:
k = 10 W/m°C, ρ = 1000 kg/m^3, C_p = 2 kJ/kg°C, h = 100 W/m^2°C

P.T.O.

SECTION - II

Q.5 **a)** What is Grashoff's number? State its physical significance. **(05)**

b) Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperatures of 427 °C and 27 °C respectively. **(05)**
Take $\varepsilon_{hot\ plate} = 0.9$ and $\varepsilon_{cold\ plate} = 0.6$.

c) Differentiate between pool boiling and forced convection boiling. **(04)**

Q.6 A room is heated by initiating fire at the fire place. The exfiltration of room air through a chimney is reduced by the use of glass door fire screen of height 0.8 m and width of 1.1 m. If the ambient air temperature is 25 °C and the surface temperature attained by the glass is 175 °C, calculate the free convection heat transfer rate from the fire place to the room. **(13)**
For this case, the following correlation is given by Churchill and Chu is valid:

$$Nu = \left(0.825 + \frac{0.387 Ra^{1/6}}{\left(1+\left(\frac{0.429}{Pr}\right)^{9/16}\right)^{8/27}} \right)^2$$

Where Ra is known as Rayleigh number and is given by

$$Ra = Gr \times Pr = \frac{g\beta\Delta T L_c^3}{\vartheta\alpha}$$

Take following properties of air:
$k = 0.0313$ W/m°C, $\nu = 22.8 \times 10^{-6}$ m^2/s, $\alpha = 32.8 \times 10^{-6}$ m^2/s, $Pr = 0.697$,
$\beta = 2.725 \times 10^{-3}$ K^{-1}

Q.7 **a)** State and explain Wien's displacement law. **(07)**

b) A thin copper sphere with its internal surface highly oxidized has a diameter of 20 cm. How small a hole must be made in the sphere to make an opening that will have an absorptive of 0.9? **(06)**

Q.8 **a)** Explain with the help of a neat sketch, boiling curve of water. **(05)**

b) Water at the rate of 0.5 kg/s is forced through a smooth 25 mm ID tube of 15 m length. The inlet water temperature is 10 °C and then tube wall is at constant temperature of 40 °C. What is the exit water temperature? **(08)**
Average properties of water are:
$C_p = 4.18$ kJ/kg°C, $\mu = 0.8 \times 10^{-3}$ Ns/m^2, $k = 0.57$ W/m°C

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