Class Test 1

Time: 40 minutes

Date: 08/02/2023

Full Marks: 20

1. A 3 cm diameter sphere containing hot liquid at 180^0C is to be insulated to reduce the heat loss to the ambient (h=2W/m^2C) at 30^0C. If fiberglass [k=0.04W/m(^{0}C)] is selected as the insulating material, compare the heat losses when the sphere is covered with the critical radius of insulation and when the sphere does not have an insulation. Please provide the derivation for critical radius of insulation for a sphere. **(10)**

2. Heat is generated uniformly at a rate of 500 MW/m^3 in a SS plate (k =20 W/m.°C) of thickness 1 cm. Derive an expression for the temperature profile in the plate when the two sides of the plate are maintained at 100 °C and 200 °C. Also estimate the temperature at the center of the plate. Mention all assumptions. **(10)**

The generalized heat conduction equation in Cartesian, cylindrical and spherical coordinates

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}+\frac{\dot{q}}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$$

$$\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}+\frac{1}{r^2}\frac{\partial^2 T}{\partial \phi^2}+\frac{\partial^2 T}{\partial z^2}+\frac{\dot{q}}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$$

$$\frac{1}{r^2}\frac{\partial^2 (rT)}{\partial r^2}+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2 T}{\partial \phi^2}+\frac{\dot{q}}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$$

Class Test 2

Time: 45 minutes

Date: 21/03/2023 at 5 p.m.

Full Marks: 25

1. Evaluate the effectiveness of a fin (k=500 W/m K) of 5 mm diameter and 250 mm length. The fin can be assumed to adiabatic at the end and the heat-transfer coefficient is $250 W/m^2K$. (5)

2. Oil with flow rate of 1000 kg/hr. and temperature of 80°C is to be cooled to 50°C. A double pipe heat exchanger is used where cooling water enters the tube at 30°C and exits at 45°C. Assuming the overall heat transfer coefficient to be $0.2 kW/m^{2}$(K) and specific heat of oil and water as 2kJ/kg (K) and 4.2kJ/kg (K) respectively, estimate the percentage saving in the heat transfer area for counter w.r.t co current flow of the two liquids. (10)

3. An aluminum rod 5.0 cm in diameter and 15 cm long protrudes from the wall that is maintained at 250°C. The rod is exposed to an environment at 25°C. The convection heat-transfer coefficient is 12 W/m^2 (°C).. Calculate (i) the heat lost by the rod (ii) the temperature profile in the rod. (5+5)

Time: 40 minutes

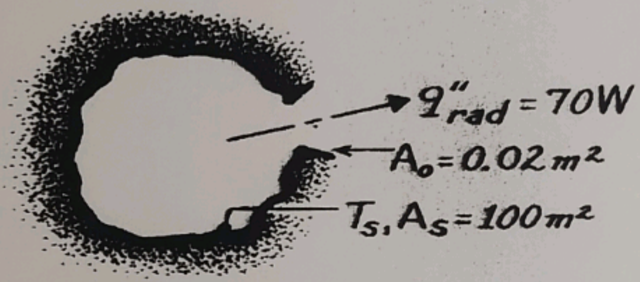
Date: 14/04/2023 at 12 noon

Full Marks: 20

1. For a surface with absorptivity twice the transmissivity and thrice the reflectivity, estimate the rate of transmitted radiation when radiant energy of intensity 800 W/m^2 is incident normally on the surface. (5)

2. A black body has a total emissive power of $4.5 kW/m^2$. Determine its surface temperature and the wavelength of maximum emission. In which range of spectrum does this emission fall? (5)

3. Consider an isothermal enclosure of surface area, A_s, having a small opening of area A_o through which 70W of radiation is emitted. Find (a) Temperature of the interior enclosure wall if the surface is black (b) Temperature of the wall surface having $\varepsilon = 0.15$. (5)



4. The filament of a tungsten filament light bulb is at temperature of 2860K. Estimate the fraction of total energy emitted by the bulb in the visible wavelength spectrum which ranges from 0.35 μm to 0.7 μm. (5)

Given: Stefan Boltzmann constant, $\sigma = 5.67\times10^{-8}\ W/(m^2.K^4)$

λT $\mu m \cdot K$	$E_{b\lambda}/T^5$ $\frac{W}{m^2\cdot K^5\cdot \mu m}\times 10^{11}$	$\frac{E_{b0-\lambda T}}{\sigma T^4}$
1000	0.02110	0.00032
1100	0.04846	0.00091
1200	0.09329	0.00213
1300	0.15724	0.00432
1400	0.23932	0.00779
1500	0.33631	0.01285
1600	0.44359	0.01972
1700	0.55603	0.02853
1800	0.66872	0.03934
1900	0.77736	0.05210
2000	0.87858	0.06672
2100	0.96994	0.08305
2200	1.04990	0.10088
2300	1.11768	0.12002
2400	1.17314	0.14025
2500	1.21659	0.16135