National Program on Technology Enhanced Learning

CONDUCTION AND RADIATION

Self- Assessment Test- 1

Duration: 50 min

Max. Marks: 40

1. Make suitable assumptions wherever required with justification
2. Assume any missing data

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(1) Assuming the earth's surface to be black, estimate its temperature if the outer surface of the sun has an equivalent temperature of 6000 K. The diameters of the sun and the earth are 1.39×10^9 and 1.29×10^7 m respectively and the distance between the sun and the earth is 1.5×10^{11} m. (8)

(2) The hemispherical spectral emissivity, ε_λ for a metal at 1300K is approximately given by

$$0 \leq \lambda \leq 2\ \mu m,\ \varepsilon_\lambda = 0.74$$
$$2 \leq \lambda \leq 4\ \mu m,\ \varepsilon_\lambda = 0.53$$
$$4 \leq \lambda \leq 6\ \mu m,\ \varepsilon_\lambda = 0.38$$
$$\lambda \geq 6\ \mu m,\ \varepsilon_\lambda = 0.17$$

The hemispherical spectral values do not change significantly with temperature.

(a) What is the hemispherical, total emissivity of the surface at 1300 K? (6)

(b) If radiation is incident on this metal surface from a blackbody at 5800 K, what is the value of α for the incident radiation? (6)

(c) What is the wavelength $\lambda_{0.5}$ for which 60% of the total radiation emitted by this surface lies in the spectral region $\lambda > \lambda_{0.5}$? (3)

(d) How does the solution to part (c) compare with the wavelength corresponding to maximum radiation for this surface? (1)

(3) Consider a directionally selective surface having the following distribution for the directional emissivity, ε_θ

$$0 \leq \theta \leq 45^\circ,\ \varepsilon_\theta = 0.85$$

$$45^{o} \leq \theta \leq 60^{\circ},\ \varepsilon_{\theta} = 0.42$$
$$60^{o} \leq \theta \leq 90^{\circ},\ \varepsilon_{\theta} = 0.24$$

The surface is isotropic in the φ direction. Calculate the ratio of the normal emissivity to the hemispherical emissivity. (6)

(4) Solar irradiation of 1150 W/m^2 is incident on a large, flat horizontal metal roof on a day when the wind blowing over the roof causes a convection heat transfer coefficient of 25 W/m^2K. The outside air temperature is 30 ºC. The solar absorptivity of the outside surface is 0.60 and the metal surface emissivity is 0.25 on the outside and 0.18 on the inside. On the inside of the roof (i.e. from below), the air temperature is the same as that on the outside but the heat transfer coefficient in only 8 W/m^2K consequent upon natural convection on the inside. There is no irradiation on the inside of the roof. Estimate the roof temperature (roof can be assumed to be very thin and hence will have the same temperature regardless of whether we are measuring it on the inside or outside) ***under steady state conditions***. (10)