Problem 12-48

The air temperature on a clear night is observed to remain at 4°C, yet the water freezes that night. Taking the convection heat transfer coefficient h = 10 W/m² °C, determine the value of the effective sky temperature that night.

The equilibrium temperature of the surface in this case is

$$\dot{q}_{net,rad} = \alpha_s G_{solar} - \varepsilon\sigma(T_s^4 - T_{sky}^4) = 0$$

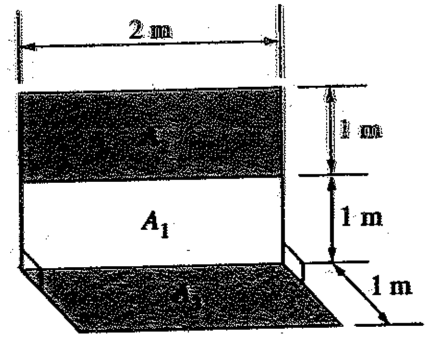
$$\alpha_s G_{solar} = \varepsilon\sigma(T_s^4 - T_{sky}^4)$$

$$0.1(1320 \text{ W/m}^2) = 0.8(5.67\times10^{-8} \text{ W/m}^2\cdot\text{K}^4)\left[T_s^4 - (0 \text{ K})^4\right]$$

$$\longrightarrow T_s = \mathbf{232.3\ K}$$

Problem 12-58

Determine the view factors F_{1-3} and F_{2-3} between the rectangular surfaces shown.



From Fig. 12-42,

$$\left.\begin{aligned} \frac{L_1}{w} &= \frac{1}{2} = 0.5 \\ \frac{L_2}{w} &= \frac{1}{2} = 0.5 \end{aligned}\right\} F_{31} = 0.24$$

and

$$\left.\begin{aligned} \frac{L_1}{w} &= \frac{1}{2} = 0.5 \\ \frac{L_2}{w} &= \frac{2}{2} = 1.0 \end{aligned}\right\} F_{3\to(1+2)} = 0.29$$

$$A_1 = A_3 \longrightarrow \text{Reciprocity rule} \longrightarrow A_1 F_{13} = A_3 F_{31} \longrightarrow F_{13} = F_{31} = \mathbf{0.24}$$

$$F_{3\to(1+2)} = F_{31} + F_{32}$$

$$0.29 = 0.24 + F_{32} \longrightarrow F_{32} = 0.05$$

$$A_2 = A_3 \longrightarrow F_{23} = F_{32} = \mathbf{0.05}$$

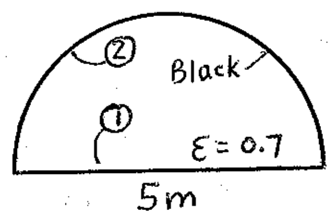
Problem 12-77

Consider a hemispherical furnace of diameter D = 5 m with a flat base. The dome of the furnace is black, and the base has an emissivity e = 0.7. The base and the dome of the furnace are maintained at uniform temperatures of 400 and 1000°K, respectively. Determine the net rate of radiation heat transfer from the dome to the base surface during steady operation.

The view factor is first determined from

$$F_{11} = 0 \quad \text{(flat surface)}$$

$$F_{11} + F_{12} = 1 \rightarrow F_{12} = 1 \quad \text{(summation rule)}$$



Noting that the dome is black, net rate of radiation heat transfer from dome to the base surface can be determined from

$$\dot{Q}_{21} = -\dot{Q}_{12} = -\varepsilon A_1 F_{12} \sigma \left(T_1^4 - T_2^4\right)$$

$$= -(0.7)\left[\pi (5\text{ m})^2 / 4\right](1)\left(5.67 \times 10^{-8}\text{ W/m}^2 \cdot \text{K}^4\right)\left[(400\text{ K})^4 - (1000\text{ K})^4\right]$$

$$= \mathbf{759{,}361\ W}$$

Problem 12-81

Two parallel black body disks of diameter D = 0.6 m and uniform temperatures of 700°K are separated by a distance L = 0.4 m and are located directly on top of each other. The back sides of each are insulated and the environmental temperature T_∞ = 300°K. Determine the rate of heat transfer from the disks to the environment.

$$F_{12} = F_{21} = 0.26$$

$$F_{13} = 1 - 0.26 = 0.74 \quad \text{(summation rule)}$$

net rate of radiation heat transfer from the disks into the environment then becomes

$$\dot{Q}_3 = \dot{Q}_{13} + \dot{Q}_{23} = 2\dot{Q}_{13}$$

$$\dot{Q}_3 = 2F_{13}A_1\sigma\left(T_1^4 - T_3^4\right)$$

$$= 2(0.74)\left[\pi(0.3\text{ m})^2\right]\left(5.67\times10^{-8}\text{ W/m}^2\cdot\text{K}^4\right)\left[(700\text{ K})^4 - (300\text{ K})^4\right] = \mathbf{5505\ W}$$