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 \( h = 10 \text{ W/m}^2\text{°C} \), determine the value of the effective sky temperature that night.

The equilibrium temperature of the surface in this case is

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

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

\[
0.1(1320 \text{ W/m}^2) = 0.8(5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4)[T_s^4 - (0 \text{ K})^4]
\]

\[\rightarrow T_s = 232.3 \text{ K}\]
Problem 12-58
Determine the view factors \( F_{1-3} \) and \( F_{2-3} \) between the rectangular surfaces shown.

From Fig. 12-42,

\[
\frac{L_1}{w} = \frac{1}{2} = 0.5 \quad \Rightarrow \quad F_{31} = 0.24
\]
\[
\frac{L_2}{w} = \frac{1}{2} = 0.5
\]

and \( F_{3 \rightarrow (1+2)} = 0.29 \)

\[
A_1 = A_3 \quad \Rightarrow \quad \text{Reciprocity rule} \quad \Rightarrow \quad A_1 F_{13} = A_3 F_{31} \quad \Rightarrow \quad F_{13} = F_{31} = 0.24
\]

\[
F_{3 \rightarrow (1+2)} = F_{31} + F_{32}
\]

\[
0.29 = 0.24 + F_{32} \quad \Rightarrow \quad F_{32} = 0.05
\]

\[
A_2 = A_3 \quad \Rightarrow \quad F_{23} = F_{32} = 0.05
\]
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 $\varepsilon = 0.7$. The base and the dome of the furnace are maintained at uniform temperatures of 400 and 1000$^\circ$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

$$\dot{Q}_{21} = -\dot{Q}_{12} = -\varepsilon A_{1} F_{12} \sigma \left(T_{1}^{4} - T_{2}^{4}\right)$$
$$= -(0.7) \left[\pi (5 \text{ m})^{2} / 4 \right] (1) (5.67 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4) \left[(400 \text{ K})^4 - (1000 \text{ K})^4\right]$$
$$= 759,361 \text{ W}$$
Problem 12-81
Two parallel black body disks of diameter $D = 0.6 \text{ m}$ and uniform temperatures of $700^\circ \text{K}$ are separated by a distance $L = 0.4 \text{ m}$ and are located directly on top of each other. The back sides of each are insulated and the environmental temperature $T_{\infty} = 300^\circ \text{K}$. Determine the rate of heat transfer from the disks to the environment.

\[
F_{12} = F_{21} = 0.26 \\
F_{13} = 1 - 0.26 = 0.74 \quad \text{(summation rule)}
\]

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

\[
\dot{Q}_3 = \dot{Q}_{13} + \dot{Q}_{23} = 2 \dot{Q}_{13} \\
\dot{Q}_3 = 2F_{13}A_1\sigma(T_1^4 - T_3^4) \\
= 2(0.74)\left[\pi(0.3 \text{ m})^2\right][5.67 \times 10^{-8} \text{ W/m}^2\cdot\text{K}^4][(700 \text{ K})^4 - (300 \text{ K})^4] = 5505 \text{ W}
\]