Problem 13.7

Consider a cylindrical enclosure with $A_1, A_2,$ and $A_3$ representing the internal base, top, and side surfaces, respectively. Using the length to diameter ratio, $K = L/D$, determine 
(a) the expression for the view factor between the base and the side surface $F_{13}$ in terms of $K$ and (b) the value of the view factor $F_{13}$ for $L = D$.

![Diagram of a cylindrical enclosure with surfaces $A_1$, $A_2$, and $A_3$.]

**Problem 13.8**

Two infinitely long parallel plates of width $w$ are located at $w$ distance apart, as shown in the figure. Using the Hottel’s crossed-strings method, determine the view factor $F_{12}$. 
Problem 13.10

Consider a cylindrical enclosure whose height is twice the diameter of its base. Determine the view factor from the side surface of this cylindrical enclosure to its base surface.

Problem 13.12

Three infinitely long parallel cylinders of diameter $D$ are located a distance $s$ apart from each other. Determine the view factor between the cylinder in the middle and the surroundings.
Problem 13.14

Consider a conical enclosure of height $h$ and base diameter $D$. Determine the view factor from the conical side surface to a hole of diameter $d$ located at the center of the base.

![Figure P13-14](image)

Problem 13.16

Determine the view factor $F_{12}$ between the rectangular surfaces shown in Fig. P13–16.

![Figure P13-16](image)

Problem 13.18

Determine the view factors from the very long grooves shown in Fig. P13–18 to the surroundings without using any view factor tables or charts. Neglect end effects.
Problem 13.20

Consider a cylindrical surface and a disk oriented coaxially as shown in the figure. The cylinder has a diameter $D$ and a length $L$. The disk of diameter $D$ is placed coaxially with the cylinder at a distance $L$. If $L = 2D$, determine the view factor $F_{12}$ between the cylindrical surface (1) and the disk (2) facing it.

Problem 13.30E

Consider a 10-ft $\times$ 10-ft $\times$ 10-ft cubical furnace whose top and side surfaces closely approximate black surfaces and whose base surface has an emissivity $\varepsilon = 0.4$. The base, top, and side surfaces of the furnace are maintained at uniform temperatures of 800 R, 1600 R, and 2400 R, respectively. Determine the net rate of radiation heat transfer between (a) the base and the side surfaces and (b) the base and the top surfaces. Also, determine the net rate of radiation heat transfer to the base surface.
Problem 13.32

Two very large parallel plates are maintained at uniform temperatures of $T_1 = 600 \text{ K}$ and $T_2 = 400 \text{ K}$ and have emissivities $\varepsilon_1 = 0.5$ and $\varepsilon_2 = 0.9$, respectively. Determine the net rate of radiation heat transfer between the two surfaces per unit area of the plates.

Problem 13.34

Two infinitely long parallel plates of width $w$ are located at $w$ distance apart, as shown in the figure. The two plates behave as black surfaces, where surface $A_1$ has a temperature of 700 K and surface $A_2$ has a temperature of 300 K. Determine the radiation heat flux between the two surfaces.

![Figure P13-34](image)

Problem 13.36

A furnace is of cylindrical shape with $R = H = 3 \text{ m}$. The base, top, and side surfaces of the furnace are all black and are maintained at uniform temperatures of 500, 700, and 1400 K, respectively. Determine the net rate of radiation heat transfer to or from the top surface during steady operation.
Problem 13.37E

A 9-ft-high room with a base area of 12 ft \(\times\) 12 ft is to be heated by electric resistance heaters placed on the ceiling, which is maintained at a uniform temperature of 90\(^\circ\)F at all times. The floor of the room is at 65\(^\circ\)F and has an emissivity of 0.8. The side surfaces are well insulated. Treating the ceiling as a blackbody, determine the rate of heat loss from the room through the floor.

Problem 13.38

Two very long concentric cylinders of diameters \(D_1 = 0.35\) m and \(D_2 = 0.5\) m are maintained at uniform temperatures of \(T_1 = 950\) K and \(T_2 = 500\) K and have emissivities \(\varepsilon_1 = 1\) and \(\varepsilon_2 = 0.55\), respectively. Determine the net rate of radiation heat transfer between the two cylinders per unit length of the cylinders.

Problem 13.39

Two black parallel rectangles with dimensions 3 ft \(\times\) 5 ft are spaced apart by a distance of 1 ft. The two parallel rectangles are experiencing radiation heat transfer as black surfaces, where the top rectangle receives a total of 180,000 Btu/h radiation heat transfer rate from the bottom rectangle. If the top rectangle has a uniform temperature of 60\(^\circ\)F, determine the temperature of the bottom rectangle.
Problem 13.40

Two parallel plates of width $W = 0.6 \text{ m}$ separated by $L = 0.4 \text{ m}$ are located directly over each other. Both plates are black and are maintained at a temperature of 450 K. The back sides of the plates are insulated, and the environment that the plates are in can be considered to be a blackbody at 300 K. Determine the net rate of radiation heat transfer from the plates to the environment.

Problem 13.41

A dryer is shaped like a long semi-cylindrical duct of diameter 1.5 m. The base of the dryer is occupied with water soaked materials to be dried. The base is maintained at a temperature of 370 K, while the dome of the dryer is maintained at 1000 K. If both surfaces behave as blackbodies, determine the drying rate per unit length experienced by the wet materials.
Problem 13.42

Two coaxial parallel disks of equal diameter 1 m are originally placed at a distance of 1 m apart. If both disks behave as black surfaces, determine the new distance between the disks such that there is a 75% reduction in radiation heat transfer rate from the original distance of 1 m.

![Figure P13-42](image)

Problem 13.43

A furnace is shaped like a long equilateral-triangular duct where the width of each side is 2 m. Heat is supplied from the base surface, whose emissivity is $\varepsilon_1 = 0.8$, at a rate of 800 W/m$^2$ while the side surfaces, whose emissivities are 0.5, are maintained at 500 K. neglecting the end effects, determine the temperature of the base surface. Treat this geometry as a two-surface enclosure.

Problem 13.45

Consider a 4-m $\times$ 4-m $\times$ 4-m cubical furnace whose floor and ceiling are black and whose side surfaces are reradiating. The floor and the ceiling of the furnace are maintained at temperatures of 550 K and 1100 K, respectively. Determine the net rate of radiation heat transfer between the floor and the ceiling of the furnace.
Problem 13.46

Two concentric spheres of diameters \( D_1 = 0.3 \text{ m} \) and \( D_2 = 0.6 \text{ m} \) are maintained at uniform temperatures \( T_1 = 800 \text{ K} \) and \( T_2 = 500 \text{ K} \) and have emissivities \( \varepsilon_1 = 0.5 \) and \( \varepsilon_2 = 0.7 \), respectively. Determine the net rate of radiation heat transfer between the two spheres. Also, determine the convection heat transfer coefficient at the outer surface if both the surrounding medium and the surrounding surfaces are at 30\(^\circ\)C. Assume the emissivity of the outer surface is 0.35.

Problem 13.47

A spherical tank of diameter \( D = 2 \text{ m} \) that is filled with liquid nitrogen at 100 K is kept in an evacuated cubic enclosure whose sides are 3 m long. The emissivities of the spherical tank and the enclosure are \( \varepsilon_1 = 0.1 \) and \( \varepsilon_2 = 0.8 \), respectively. If the temperature of the cubic enclosure is measured to be 240 K, determine the net rate of radiation heat transfer to the liquid nitrogen.

Problem 13.50

Consider a circular grill whose diameter is 0.3 m. The bottom of the grill is covered with hot coal bricks at 950 K, while the wire mesh on top of the grill is covered with steaks initially at 5\(^\circ\)C. The distance between the coal bricks and the steaks is 0.20 m. Treating both the steaks and the coal bricks as blackbodies, determine the initial rate of radiation heat transfer from the coal bricks to the steaks. Also, determine the initial rate of radiation heat transfer to the steaks if the side opening of the grill is covered by aluminum foil, which can be approximated as a reradiating surface.
Problem 13.51

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 of 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.

Problem 13.52

Consider two rectangular surfaces perpendicular to each other with a common edge which is 1.6 m long. The horizontal surface is 0.8 m wide and the vertical surface is 1.2 m high. The horizontal surface has an emissivity of 0.75 and is maintained at 450 K. The vertical surface is black and is maintained at 700 K. The back sides of the surfaces are insulated.

The surrounding surfaces are at 290 K, and can be considered to have an emissivity of 0.85. Determine the net rate of radiation heat transfers between the two surfaces, and between the horizontal surface and the surroundings.
Problem 13-53

Two long parallel 20-cm-diameter cylinders are located 30 cm apart from each other. Both cylinders are black, and are maintained at temperatures 425 K and 275 K. The surroundings can be treated as a blackbody at 300 K. For a 1-m-long section of the cylinders, determine the rates of radiation heat transfer between the cylinders and between the hot cylinder and the surroundings.
Problem 13.56

Consider a hot cylindrical surface and a disk oriented as shown in the figure. Both the cylindrical surface and the disk behave as blackbody. The cylinder has a diameter $D$ and a length $L$ of 0.2 m. The disk of diameter $D = 0.2$ m is placed coaxially with the cylinder at a distance of $L = 0.2$ m apart. The cylindrical surface and the disk are maintained at uniform temperatures of 1000 K and 300 K, respectively. Determine the rate of heat transfer by radiation from cylindrical surface to the disk.

![Figure P13-56](image)

**Problem 13.58**

Two-phase gas-liquid oxygen is stored in a spherical tank of 1-m diameter, where it is maintained at its normal boiling point. The spherical tank is enclosed by a 1.6-m diameter concentric spherical surface at 273 K. Both spherical surfaces have an emissivity of 0.01, and the gap between the inner sphere and outer sphere is vacuumed. Assuming that the spherical tank surface has the same temperature as the oxygen, determine the heat transfer rate at the spherical tank surface.
**Problem 13.62**

Two very large parallel plates are maintained at uniform temperatures of $T_1 = 1100 \text{ K}$ and $T_2 = 700 \text{ K}$ and have emissivities of $\varepsilon_1 = \varepsilon_2 = 0.5$, respectively. It is desired to reduce the net rate of radiation heat transfer between the two plates to one-fifth by placing thin aluminum sheets with an emissivity of $0.1$ on both sides between the plates. Determine the number of sheets that need to be inserted.

**Problem 13.64**

A thin aluminum sheet with an emissivity of $0.15$ on both sides is placed between two very large parallel plates, which are maintained at uniform temperatures $T_1 = 900 \text{ K}$ and $T_2 = 650 \text{ K}$ and have emissivities $\varepsilon_1 = 0.5$ and $\varepsilon_2 = 0.8$, respectively. Determine the net rate of radiation heat transfer between the two plates per unit surface area of the plates and compare the result with that without the shield.
Problem 13.66

Consider a person whose exposed surface area is 1.9 m², emissivity is 0.85, and surface temperature is 30°C. Determine the rate of heat loss from that person by radiation in a large room whose walls are at a temperature of (a) 295 K and (b) 260 K.

Problem 13.69

Liquid nitrogen is stored in a spherical tank of 1-m diameter, where tank surface is maintained uniformly at 80 K. The spherical tank is enclosed by a 1.6-m diameter concentric sphere with uniform surface temperature of 273 K. Both spherical surfaces have an emissivity of 0.01, and the gap between the inner sphere and outer sphere is vacuumed. Determine the rate of vaporization for the liquid nitrogen.
Problem 13.70E

Two parallel disks of diameter $D = 3$ ft separated by $L = 2$ ft are located directly on top of each other. The disks are separated by a radiation shield whose emissivity is 0.15. Both disks are black and are maintained at temperatures of 1350 R and 650 R, respectively. The environment that the disks are in can be considered to be a blackbody at 540 R. Determine the net rate of radiation heat transfer through the shield under steady conditions.

FIGURE P13-70E
Problem 13.73

Two coaxial cylinders of diameters \( D_1 = 0.20 \text{ m} \) and \( D_2 = 0.50 \text{ m} \) and emissivities \( \varepsilon_1 = 0.7 \) and \( \varepsilon_2 = 0.4 \) are maintained at uniform temperatures of \( T_1 = 750 \text{ K} \) and \( T_2 = 500 \text{ K} \), respectively. Now a coaxial radiation shield of diameter \( D_3 = 0.20 \text{ m} \) and emissivity \( \varepsilon_3 = 0.2 \) is placed between the two cylinders. Determine the net rate of radiation heat transfer between the two cylinders per unit length of the cylinders and compare the result with that without the shield.

Problem 13.75

A long cylindrical black surface fuel rod of diameter 25 mm is shielded by a surface concentric to the rod. The shield has diameter of 50 mm, and its outer surface is exposed to surrounding air at 300 K with a convection heat transfer coefficient of 15 W/m²⋅K. Inner and outer surfaces of the shield have an emissivity of 0.05, and the gap between the fuel rod and the shield is a vacuum. If the shield maintains a uniform temperature of 320 K, determine the surface temperature of the fuel rod.

![Diagram](image-url)
Problem 13-76E

A 9-ft-high room with a base area of 12 ft × 12 ft is to be heated by electric resistance heaters placed on the ceiling, which is maintained at a uniform temperature of 90°F at all times. The floor of the room is at 65°F and has an emissivity of 0.8. The side surfaces are well insulated. Treating the ceiling as a blackbody, determine the rate of heat loss from the room through the floor.