Problem 12.18

The temperature of the filament of an incandescent light bulb is 2500 K. Assuming the filament to be a blackbody, determine the fraction of the radiant energy emitted by the filament that falls in the visible range. Also, determine the wavelength at which the emission of radiation from the filament peaks.

Problem 12.20

Consider a surface at a uniform temperature of 1000 K. Determine the maximum rate of thermal radiation that can be emitted by this surface, in W/m².

Problem 12.22E

The sun can be treated as a blackbody at an effective surface temperature of 10,400 R. Determine the rate at which infrared radiation energy (λ = 0.76 – 100 μm) is emitted by the sun, in Btu/h ft².

Problem 12.24

The temperature of the filament of an incandescent light bulb is 2800 K. Treating the filament as a blackbody, determine the fraction of the radiant energy emitted by the filament that falls in the visible range. Also, determine the wavelength at which the emission of radiation from the filament peaks.

Problem 12.26

Consider a 20-cm × 20-cm × 20-cm cubical body at 900 K suspended in the air. Assuming the body closely approximates a blackbody, determine (a) the rate at which the cube emits radiation energy, in W and (b) the spectral blackbody emissive power at a wavelength of 4 μm.

Problem 12.28

A 3-mm-thick glass window transmits 90 percent of the radiation between λ = 0.3 and 3.0 μm and is essentially opaque for radiation at other wavelengths. Determine the rate of radiation transmitted through a 3-m × 3-m glass window from blackbody sources at (a) 5800 K and (b) 1000 K.
Problem 12.30

A flame from a match may be approximated as a blackbody at the effective surface temperature of 1700 K, while moonlight may be approximated as a blackbody at the effective surface temperature of 4000 K, respectively. Determine the peak spectral blackbody emissive power for both lighting sources (match flame and moonlight).

Problem 12.36

A small surface of area $A_1 = 3 \text{ cm}^2$ emits radiation as a blackbody, and part of the radiation emitted by $A_1$ strikes another small surface of area $A_2 = 8 \text{ cm}^2$ oriented as shown in the figure. If the rate at which radiation emitted by $A_1$ that strikes $A_2$ is measured to be $274 \times 10^{-6} \text{ W}$ determine the intensity of the radiation emitted by $A_1$, and the temperature of $A_1$.

Problem 12.38

A small circular surface of area $A_1 = 2 \text{ cm}^2$ located at the center of a 2-m-diameter sphere emits radiation as a blackbody at $T_1 = 1000 \text{ K}$. Determine the rate at which radiation energy is streaming through a $D_2 = 1$-cm-diameter hole located $(a)$ on top of the sphere directly above $A_1$ and $(b)$ on the side of sphere such that the line that connects the centers of $A_1$ and $A_2$ makes $45^\circ$ with surface $A_1$. 
Problem 12.40

A small surface of area \( A_1 = 7 \text{ cm}^2 \) emits radiation as a blackbody at \( T_1 = 800 \text{ K} \). Part of the radiation emitted by \( A_1 \) strikes another small surface of area \( A_2 = 7 \text{ cm}^2 \) oriented as shown in the figure. Determine the solid angle subtended by \( A_2 \) when viewed from \( A_1 \), and the rate at which radiation emitted by \( A_1 \) strikes \( A_2 \) directly.

![Figure P12-40](image)

Problem 12.42

Consider the intensity of solar radiation incident on earth’s surface can be expressed as \( I_i = 100 \cos \theta \), where \( I_i \) has the units of \( \text{W/m}^2 \cdot \text{sr} \). Determine the peak value for the intensity of incident solar radiation, and the solar irradiation on earth’s surface.

Problem 12.44

Consider an aperture of 10-mm diameter through which radiation is emitted as a blackbody with an emissive power of \( 2.87 \times 10^5 \text{ W/m}^2 \). A radiation sensor is positioned with a 30° tilt off the normal direction of viewing, as shown in the figure. If the sensor is sensing an irradiation of 50 W/m², determine the distance between the aperture and the sensor.
Problem 12.50

Consider an opaque horizontal plate of area 1 m² that is well insulated on the edges and the lower surface. The plate is maintained at 500 K, has a total hemispherical absorptivity of 0.51 and the following spectral emissivity function:

\[ \varepsilon_\lambda = \begin{cases} 
0.4, & 0 \leq \lambda < 4 \mu m \\
0.8, & 4 \mu m \leq \lambda < \infty 
\end{cases} \]

If the plate is subjected to an irradiation of 5600 W/m², determine (a) the total hemispherical emissivity, (b) the radiosity of the plate surface, and (c) the heat transfer rate required to maintain the stated temperature.

Problem 12.52E

A 5-in-diameter spherical ball is known to emit radiation at a rate of 480 Btu/h when its surface temperature is 950 R. Determine the average emissivity of the ball at this temperature.

Problem 12.54

The emissivity of a tungsten filament can be approximated to be 0.5 for radiation at wavelengths less than 1 μm and 0.15 for radiation at greater than 1 μm. Determine the average emissivity of the filament at (a) 1500 K and (b) 2500 K. Also, assuming that Kirchhoff’s law applies to this situation, determine the absorptivity and reflectivity of the filament at both temperatures.
Problem 12.56

The emissivity of a surface coated with aluminum oxide can be approximated to be 0.15 for radiation at wavelengths less than 5 \(\mu\)m and 0.9 for radiation at wavelengths greater than 5 \(\mu\)m. Determine the average emissivity of this surface at (a) 5800 K and (b) 300 K. What can you say about the absorptivity of this surface for radiation coming from sources at 5800 K and 300 K?

Problem 12.58

The reflectivity of aluminum coated with lead sulfate is 0.35 for radiation at wavelengths less than 3 \(\mu\)m and 0.95 for radiation greater than 3 \(\mu\)m. Determine the average reflectivity of this surface for solar radiation \((T \approx 5800 \text{ K})\) and radiation coming from surfaces at room temperature \((T \approx 300 \text{ K})\). Also, determine the emissivity and absorptivity of this surface at both temperatures. Do you think this material is suitable for use in solar collectors?

Problem 12.60

Consider an opaque horizontal plate that is well insulated on the edges and the lower surface. The plate is uniformly irradiated from above while air at \(T_\infty = 300\) K flows over the surface providing a uniform convection heat transfer coefficient of 40 W/m\(^2\)-K. Under steady state conditions the surface has a radiosity of 4000 W/m\(^2\), and the plate temperature is maintained uniformly at 350 K. If the total absorptivity of the plate is 0.40, determine (a) the irradiation on the plate, (b) the total reflectivity of the plate, (c) the emissive power of the plate, and (d) the total emissivity of the plate. Assume that Kirchhoff’s Law is not valid in this situation.

![Figure P12-60](image-url)
Problem 12.62

A horizontal plate is experiencing uniform irradiation on the both upper and lower surfaces. The ambient air temperature surrounding the plate is 290 K with a convection heat transfer coefficient of 30 W/m²·K. Both upper and lower surfaces of the plate have a radiosity of 4000 W/m², and the plate temperature is maintained uniformly at 390 K. If the plate is not opaque and has an absorptivity of 0.527, determine the irradiation and emissivity of the plate.

![](image)

**FIGURE P12-62**

Problem 12.70

The air temperature on a clear night is observed to remain at about 4°C. Yet water is reported to have frozen that night due to radiation effect. Taking the convection heat transfer coefficient to be 18 W/m²·K, determine the value of the maximum effective sky temperature that night.

Problem 12.72

A surface has an absorptivity of $\alpha_s = 0.72$ for solar radiation and an emissivity of $\varepsilon = 0.6$ at room temperature. The surface temperature is observed to be 350 K when the direct and the diffuse components of solar radiation are $G_D = 350$ and $G_D = 400$ W/m², respectively, and the direct radiation makes a 30° angle with the normal of the surface. Taking the effective sky temperature to be 280 K, determine the net rate of radiation heat transfer to the surface at that time.