

33. **REASONING** The fraction of the sun's power that is intercepted by Mercury is the power $P_{\text{intercepted}}$ intercepted by Mercury divided by the power P_{sun} radiated by the sun, or $\text{Fraction} = P_{\text{intercepted}} / P_{\text{sun}}$. According to Equation 16.8, the power intercepted by Mercury is the intensity S of the radiation at Mercury's location times the area A that Mercury presents to the radiation. Since the sun radiates uniformly in all directions, we can use Equation 16.9 to evaluate the intensity at Mercury's location. The planet Mercury looks like a circular disk to the radiation (just like the moon looks like a disk to anyone viewing it); this area is $A = \pi r_{\text{Mercury}}^2$, where r_{Mercury} is the radius of Mercury.

SOLUTION The fraction of the sun's power that is intercepted by Mercury is

$$\text{Fraction} = \frac{\text{Power intercepted by Mercury}}{\text{Power radiated by sun}} = \frac{P_{\text{intercepted}}}{P_{\text{sun}}} \quad (1)$$

According to Equation 16.8, the power $P_{\text{intercepted}}$ by Mercury is equal to the intensity S of the radiation at Mercury times the area A of the Mercury disk, or $P_{\text{intercepted}} = SA$. Substituting this expression into Equation (1) gives

$$\text{Fraction} = \frac{P_{\text{intercepted}}}{P_{\text{sun}}} = \frac{SA}{P_{\text{sun}}} \quad (2)$$

Since the sun radiates uniformly in all directions, the intensity of the radiation at Mercury's location is $S = P_{\text{sun}} / 4\pi r^2$ (Equation 16.9), where r is the mean distance from the sun to Mercury. As mentioned in the **REASONING** section, the area of the Mercury disk is $A = \pi r_{\text{Mercury}}^2$. Substituting these expressions for S and A into Equation (2) yields

$$\begin{aligned} \text{Fraction} &= \frac{SA}{P_{\text{sun}}} = \frac{\frac{P_{\text{sun}}}{4\pi r^2} (\pi r_{\text{Mercury}}^2)}{P_{\text{sun}}} = \frac{r_{\text{Mercury}}^2}{4r^2} \\ &= \frac{(2.44 \times 10^6 \text{ m})^2}{4(5.79 \times 10^{10} \text{ m})^2} = \boxed{4.44 \times 10^{-10}} \end{aligned}$$
