A grey space capsule is sent on a trip to the Moon. The surface is designed to reflect 50% of the incident sunlight (i.e. it is "grey" for wavelengths less than about 3 or 4 μm). The total intensity of radiation emitted by the surface (wavelengths longer than about 3 or 4 μm) are still described by σT^4.

The capsule is spherical and has a radius of 3 meters.

The space capsule reaches thermal equilibrium after being bathed in sunlight for a few hours. The capsule is rotating and is made of thermally conducting metal, so that all sides have the same temperature. Find the temperature.

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Figure 1: **Hint:** The energy of the sunlight absorbed by a sphere can be calculated by finding the area of the shadow, which is also known as its cross-sectional area.

Solution We start by drawing an energy flow diagram.

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The incoming energy from the sun is $\left[1360\frac{\text{J}}{\text{s}\cdot\text{m}^2}\right]\pi r^2$, which comes from a circle with radius 3 meters. The reflected radiation is half of the incoming radiation. The blackbody emission is $(\sigma T^4)(4\pi r^2)$, which uses the area of a sphere.

$$\text{energy rate in} = \text{energy rate out} \tag{1}$$

$$I_\odot \cancel{\pi r^2} = \frac{1}{2} I_\odot \cancel{\pi r^2} + \sigma T^4 4 \cancel{\pi r^2} \tag{2}$$

$$\frac{1}{2} I_\odot = 4\sigma T^4 \tag{3}$$

$$T^4 = \frac{I_\odot}{8\sigma} \tag{4}$$

$$T = 234 \text{ K} \tag{5}$$

Sadly, this is too chilly for me. I guess I'll need to open a window on the sunny side?