

In this problem we will estimate the temperature of some planets. To accomplish this, you will need to know the following information:

	Radius	Albedo	Actual Temperature	Estimated Temperature
Sun	$7 \times 10^8 \text{ m}$		5800 K	
Venus' Orbit	$1.1 \times 10^{11} \text{ m}$	65%	735 K	
Earths' Orbit	$1.5 \times 10^{11} \text{ m}$	30%	290 K	
Mars' Orbit	$2.3 \times 10^{11} \text{ m}$	15%	213.5 K	

The albedo of a planet is the percent of solar radiation that gets reflected by the atmosphere. This radiation doesn't contribute to the heat budget of the planet.

a) Assume the Sun is a 'blackbody'. Although the Sun is much hotter (and hence emits more energy) than the planets, a planet only receives a small fraction of it. Write down a formula for the Sun's flux at a planet as a function of its orbital radius.

b) For a planet's temperature to remain approximately constant, the thermal radiation it receives from the Sun is balanced by the thermal radiation it emits. Also assuming the planets are a blackbody, write down a formula to estimate the temperature of a planet as a function of its orbital radius and albedo. Assume that the planet absorbs as a disc but radiates as a sphere. Compute the estimated temperatures for the four planets listed above. Which planets does this accurately compute the temperature for?

c) Calculate the maximum wavelength radiated by the Sun and the Earth.

d) We notice that our estimate for the temperature of the Earth is off by 35 K. This is because we've ignored any effect of greenhouse gases. Assume that greenhouse gases reflect approximately 35% of the radiation emitted by the Earth back to the Earth (but completely transmit the solar radiation to heat the earth). Now, compute the temperature of the Earth. How does it compare to the actual temperature?

Notice, that Venus' temperature is significantly off. This is because greenhouse gasses on Venus reflect approximately 99% of the radiation emitted by Venus back to the planet surface. If you were to redo part (d) for Venus you would get approximately the right temperature.