Quiz #4 Answers

Power/area=σT^4	$\sigma=5.7*10^{-8}$ W/(m^2 * Kelvin^4)	$\lambda_{max}=2.9*10^6$/(T [Kelvin]) nm
$F=(GM_1M_2)/d^2$	$E=(GM_1M_2)/d$	$G=6.67*10^{-11}$ m^3/(s^2*kg)

1. You have been told since you were young that when you heat air it expands and when you cool it, it contracts. You can easily see this with a beach ball. If it is fully inflated outside on a hot day, it will be under inflated when you take it into an air conditioned building. Why is this? What is really changing with the heating and cooling?

When the beach ball cools, it is really just removing thermal energy from the air which slows down the molecules in the air. When the slow they have fewer collisions with the walls of the beach ball and those collisions have less energy. As such, the beach ball falls in a bit and we see it as deflating some.

Note that the atoms/molecules are not changing size. They are changing speed.

2. The filament in a standard light bulb is heated to about 3000K when the light is turned on. Assuming that it is a 100W light bulb, how large is the surface area of the filament in m^2?

$$P/A=\sigma T^4$$

$$A=\frac{P}{\sigma T^4}=\frac{100[W]}{5.7\times10^{-8}(3000)^4[W/m^2]}=\frac{100[W]}{5.7\times10^{-8}*81\times10^{12}[W/m^2]}$$

$$\frac{100[W]}{462\times10^4[W/m^2]}=2.2\times10^{-5}[m^2]$$

This problem was very frustrating to grade because of the number of people who messed up the algebra even after picking the right formula. Lots of people told me that their light bulb filament had a bigger surface area than a football field. That should sent off flags that something went wrong.

Extra Credit: How can light tell you the speed at which an object is rotating?

If an object is rotating, then part of it is moving toward you while part of it is moving away from you. The Doppler shift causes small changes in the wavelength of light emitted from the two sides of the object. This causes emission or absorption lines to be more spread out instead of being at a single frequency. This last part is critical. We can almost never resolve the disk of objects in the night sky. They are simply too small. So you never get a clear signal from the two sides. Instead, it is the broadening of the spectral lines that you are really able to observe.