1. **Estimate the number of visible photons leaving a 60W light bulb per second.**

No of visible photons per second = no of joules per second
ˊ no of photons per joule
ˊ no of visible photons per photon

The last term there is the efficiency of the bulb because it also emits energy as infra-red, invisible photons.

If you look at the formula and replace 'per' with a division sign you can see it as a kind of algebraic formula:

= ˊ ˊ

If you cancel joules top and bottom, and photons top and bottom then the two sides of the equation balance. This is a trick you can use to create formulae in many circumstances - it is especially helpful in keeping track of when things are per second, per year etc.

Let's look at each of the terms in the equation:

is just the power of the bulb which we are given, 60W.

might be more recognisable the other way up. Joules per photon is the energy per photon given by the formula E=hf where h is Planck's constant and f is the frequency of the light. It might be easiest to use c=fl and estimate the wavelength. Visible light is in the range 400-700nm so we shall use 500nm as the mean wavelength.
So now E= and photons per joule is .

is the efficiency of the bulb. A typical incandescent bulb (like a tungsten bulb, as opposed to a fluorescent bulb) puts out about 95% heat and 5% visible light.

Putting all that into our formula we get

No of visible photons per second = 60 ˊ ˊ 0.05
= 8ˊ1018 photons/second.

2. **How big would a sandcastle be if you made it from the same number of grains of sand as there are atoms in a single grain of sand?**

Assuming the sand consists of silicon dioxide (SiO_2), 1 mole would have a mass of 60 g and contain Avogadro's number (6 x 10^23) of SiO_2 'units'. Let's assume a density of 3000 kg/m³. Modelling a grain as a cube of side length 1 mm gives a volume of 1 x 10^-9 m³. The mass would therefore be 3 x 10^-3 g. This grain of sand contains (3 x 10^-3 g / 60 g) x (6 x 10^23) x 3 atoms per unit of silicon dioxide = 9 x 10^19 atoms per grain of sand. That number of grains, each with a volume of 1 x 10^-9 m³ would give a volume of 9 x 10^10 m³. Or a cubic sandcastle with sides of 4 km!
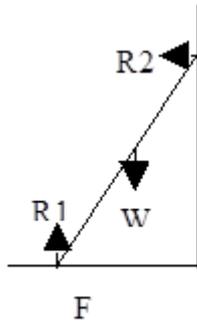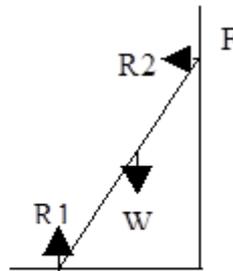
3. A ladder can rest on a rough floor against a smooth wall but not on a smooth floor against a rough wall. Why?

This is most easily seen by looking at the diagrams with all the forces drawn in:

Rough floor, smooth wall   Rough wall, smooth floor

Resolve the forces in the vertical and horizontal directions.

Vertical: $R_1 = W$ $R_1 + F = W$

Horizontal: $R_2 = F$ $R_2 = ?$

In the second case there is no force to resist the reaction of the ladder leaning against the wall. The ladder simply slides out to the left.