$E = mc^2$

Let's spend some time on the most famous equation in Physics!

In our unitless world we have the rest energy equal to the mass. Back in the MKS world we have $E = mc^2$ instead.

Consider a fission reaction that takes place inside a nuclear reactor, where the collision of a neutron and a uranium nucleus results in two smaller nuclei, with the release of some energy.

$${}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{236}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + \_\_\ {}^{1}_{0}n$$

How many neutrons are involved on the right-hand side?

The relevant masses involved here are:

Object	**Mass (*u*)**
Neutron	1.008665
U-235	235.043924
U-236	236.045562
Barium-141	140.914363
Krypton-92	91.926270

1 *u* = 1.6605 x 10^{-27} kg.

How much mass is missing on the right-hand side?

If we convert that mass to energy what do we get?

Estimate how many kg of U-235 must be split up to provide power for a city of 6 million people for a year.

Annihilation is the name given to the process of converting mass entirely into energy, which can occur when a particle encounters its anti-particle. An example of this is when a slow-moving electron encounters a slow-moving positron. In this case let's take 1 mass unit to represent the mass of an electron (and a positron, which has the same mass).

Can the annihilation of the electron-positron pair produce a single photon? Why or why not? Can it produce two photons? Sketch momenergy diagrams to show whether either of these two cases is possible.

Let's see how far we get with exercise 8-14, which is similar to the above except that the collision involves a fast-moving positron (mass m, kinetic energy K) colliding with an electron (mass m) that is at rest. The annihilation event causes two photons to be emitted, one traveling in the same direction the positron was going and the other in exactly the opposite direction.

Find an expression for the energy of each photon. The expressions should not involve velocity.

Evaluate your expressions in the limiting case of very large K.