Physics 211 Week 7 Momentum: Gone Fission

When a Uranium-235 nucleus decays, two lighter nuclei are ejected with high kinetic energy. It is this energy that is harnessed in reactors (and bombs). A pair of neutrons is typically also ejected, each of which can cause another ^{235}U nucleus to fission, leading to a chain reaction.

A fun way to model a ^{235}U nucleus is to say that it is really composed of two lighter nuclei, call them A and B. Say nucleus A has a mass of 90 amu (atomic mass units), and nucleus B has a mass of 145 amu, and that initially A and B are at rest and have a massless spring squeezed between them. We will also need to pretend that there is something holding the pair together, preventing them from being blown apart by the spring (a little latch, say). When a neutron happens to bump into this setup it releases the latch, allowing the spring to expand, sending A and B off in opposite directions at high speed. The total kinetic energy of A and B (the uranium fission products) after this happens is known to be about 200 MeV.

Use this simple model to figure out the following:

1. What are the speeds of both A and B after the ^{235}U nucleus fissions?
2. Assuming the spring was initially compressed 10 femtometers (the size of a nucleus), what is the spring constant?

Useful conversions: 1 amu = 1.7×10^{-27} kg
1 MeV = 1.6×10^{-13} J
1 femtometer = 10^{-15} m

Part 1 uses conservation of momentum. When A and B are released in opposite directions, the initial zero momentum of the system is conserved. The sum of the kinetic energies is also given. You can create a system of equations using the energy equation and momentum equation. Solve the system to obtain the speeds of A and B. A moves at 1.61×10^{7} *m/s* and B moves at 9.97×10^{6} *m/s*.

Part 2 uses conservation of energy. The total kinetic energy of A and B must have come from the energy stored in the spring before it was released. Set the spring potential energy equal to the given value for the total kinetic energy, solve for the spring constant, and you should obtain a spring constant of 6.4×10^{17} *N/m*.