# HW 4

Due October 23, 2009

Please answer all questions clearly and concisely. While you need not transcribe the question completely, it should be clear from your answer alone what you are talking about.

You are strongly encouraged to discuss the homework with your classmates, but you must complete the written homework by yourself, and of course, the material you submit must be your own.

Remember, show all of your work!

1. I drop a 0.1 kg ball from a height of 10m (assuming no air resistance).
   (a) How much work does gravity do on the ball on its way to the ground?
   (b) What is the speed of the ball when it hits the ground?
   (c) Using your projectile motion equations (not using energy), how long did the ball take before hitting the ground?
   (d) At constant acceleration, and only using your result from part c), what will the speed of the ball be when it hits the ground? Compare this answer to that found in part b.

2. Consider a 6 kg block moving at 0.5c.
   (a) What is the momentum of the block?
   (b) What is the rest energy of the block?
   (c) What is the Kinetic energy of the block? (**Hint:** do *not* use the relation you learned in high school.)
   (d) If I then do $5 \times 10^{17} J$ of work on the block (admittedly, quite a lot – it's about the same amount of radiant energy the earth gets from the sun every 3 seconds), what will its speed be afterwards?

3. The following nuclear reaction is known to occur:

$$n \rightarrow p + e^{-} + \nu_e$$

   The neutrino has such low mass that you may assume (for now) that it is massless.
   (a) The neutron starts at rest. What is its energy?
   (b) After the decay, what is the mass-energy of the proton and electron (and their total)?
   (c) What is the total kinetic energy of the proton, electron, and neutrino?
   (d) SUPPOSE (remember, this isn't true, but just pretend) that the neutron decays into just the proton and the electron. How fast will the electron fly out? This is a toughie, and you may want to use a computer, or do trial and error. But as a hint, realize that you know that the total momentum of proton and electron has to add up to zero, and the total energy has to add up to your answer in part c. This uniquely gives the energy for both.
   (e) Adding a 3rd particle (the neutrino), how would you expect that to affect the speed of the electron?

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