Assignment VI, HONS 157 (Honors Physics I)
Fall 2015
Due 10/9/15 at start of class

1. The Large Hadron Collider in Switzerland is the largest machine in the world. It is a machine that accelerates subatomic particles to very high Kinetic energies. Currently, the LHC can accelerate particles to about 13 TeV.

   a) What is 13 TeV in Joules?

   b) If a baseball had a Kinetic Energy of 13 TeV, how fast would it be moving? (You might be surprised by your answer).

   c) If you gave an electron an energy of 13 TeV, how fast would it be moving? (Your answer here won't be right....the formula for Kinetic Energy we know is actually only valid for speeds small compared to the speed of light. A refinement of this relationship will be introduced if you take PHYS 230. For now, report the speed as your current equation for Kinetic Energy says it would be, but realize that your answer really isn't right – nothing can move faster than light (3×10^8 m/s).

2. At any given time, approximately 1360 Watts of power are hitting each square meter of the Earth's surface due to the Sun. (Well, the side facing the sun is getting that much energy). It is a little more complicated than this, because certain areas (e.g. the poles) aren't getting direct sunlight. The total energy from the sun hitting the whole Earth each second can be reasonably approximated by assuming the Earth is a circle (not a sphere) with radius equal to Earth's radius and multiplying by the incoming power per unit area from the Sun.

   a) Based on this information (and perhaps some Googling of Earth's properties), how much solar energy hits the surface of the Earth each day?

   b) The going rate for energy in South Carolina from the power company is 9.74 cents per kiloWatt-hour. How much money could you get if you sold energy at the same rate as the power company and could harness all the Earth's solar energy for one day?

3. A car of mass 1500 kg is initially moving at a speed of 30 m/s.

   a) How much Kinetic Energy does the car have?

   b) The engine suddenly turns off and begins to coast while the car simultaneously moves onto a surface where we can state that the appropriate coefficient of friction of the tires with the road is 0.3 (and, as such, the car starts to slow down). How far does the car travel on this new surface before it loses half of its initial speed?

   c) Same scenario as part (b), but now we want to know how far does the car travel on the new surface until it loses half of its initial kinetic energy?

   d) How far does the car travel before it loses all of its kinetic energy (e.g. it reaches a stop).

   e) Based on your answers to parts b-d, what can you say about the kinetic energy as a function of traveled distance? Sketch a graph of K as a function of d.

   f) Based on your answers to parts b-d, what can you say about the kinetic energy as a function of time? Sketch a graph of K as a function of t.

4. If you drop a ball on the ground, you will usually find that the ball bounces to a height smaller than the original height you dropped it from. There are a couple of different reasonable hypotheses associated with this process. Either (i) the ball loses a constant fraction of its kinetic energy each time it bounces, or (ii) the ball loses a constant fraction of its instantaneous speed each time it bounces. Let's look at both of these possibilities in turn.

   a) You drop a ball (from rest) at a height H above the surface of the Earth. How fast is it moving immediately before impacting the surface of the Earth? (You can use Kinematic equations to figure this out. Leave your answer symbolically).

   b) If the ball retains some fraction α of its kinetic energy each time it bounces (with α a constant somewhere between 0 and 1), how high does the ball reach on its first bounce?

   c) Same scenario as part (b), but now we want to find out how high the ball reaches on its second bounce.

   d) Same scenario as parts (b-c), but now we want to find out how hight the ball reaches on its nth bounce.

   e) What is the total distance (not displacement!) that the ball travels? (Your answer should not be infinity! This is converging sequence. If you haven't seen it before, you may have to google "geometric series" to get a little help here).

   f) If the ball retains some fraction β of its *velocity* each time it bounces (with β a constant somewhere between 0 and 1), how high would the ball reach on its first bounce?

   g) Same scenario as part (f), but now the second bounce.

   h) Same scenario as parts (f-g), but now the nth bounce.

   i) What is the total distance the ball travels in this case?

5. Do two different observers necessarily agree on the kinetic energy of an object? Why or why not? If your answer is "no", give me an example of a scenario where two observers would disagree on the kinetic energy of an object.

6. Remember the projectile motion lab (with the cannons)? Let's say that when firing the ball bearings, the projectiles left the cannon moving at 5.2 m/s. Let's also say that the projectiles had a mass of 23 g (a total guess on my part).

   a) How much kinetic energy did the projectile have upon leaving the cannon?

   b) If the spring was compressed 4.6 cm to obtain the energy required to launch the projectile, what was the spring constant of the spring? (You may assume – though it isn't really true – that all of the spring energy went into kinetic energy of the projectile).

   c) If the spring needed to be compressed 4.6 cm to launch the projectile, how much force did you need to apply in order to load the cannon?

   d) If the higher setting (with the same spring) launched the projectile at 8.4 m/s, how far did you have to compress the spring for this setting?