**Assignment VI, PHYS 111 (General Physics I)**
**Fall 2016**
**Due 10/14/16 at start of class**

As always, please put your clearly written answers on separate paper.

1. The Earth has a mass of about $5.97 \times 10^{24}$ kg. Our moon has a mass of about $7.34 \times 10^{22}$ kg. The average Earth-moon distance varies a bit during the lunar orbit, but averages about $3.8 \times 10^8$ m. There is a point somewhere between the Earth and the moon where the gravitational pull from the Earth is exactly balanced by the gravitational pull from the moon in the opposite direction. How far from the center of the moon is this point? (where the Earth and moon's gravitational pulls are equal and opposite?)

2. The mass of Io (a moon of Jupiter) is about $8.9 \times 10^{22}$ kg. Its radius is $1.8 \times 10^6$ m.

   a) How long would it take a stone dropped from rest 10 meters above the surface of Io to reach the surface of Io?

   b) Let's assume that Io is a homogeneous sphere. If that's the case, what is the density of the moon?

   c) Remember that only the mass still closer to the center of an object matters in determining gravitational acceleration. Given this – and your answers to the problems above and/or the problem statement, what would the value of $\vec{g}$ on Io be at the bottom of a hole dug 1/3 of the way to Io's core?

3. A 5.50-kg block is pushed up an incline that is raised 15° above the horizontal. The kinetic coefficient of friction between the block and the incline is 0.35. The block is pushed with a purely horizontal force (parallel to the floor) that is sufficiently large to result in a fixed acceleration of 2.3 m/s$^2$ up the incline. The total distance from the bottom of the incline to the top of the incline is 25 meters.

   a) What is the magnitude of the applied force?

   b) What is the total work done by the applied force when the block moves from the bottom of the incline to the top of the incline?

   c) What is the total work done by friction as the block slides up the incline?

   d) What is the total work done by gravity as the block slides up the incline?

4. 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 ($3 \times 10^8$ m/s).)

5. 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 $t$.

6. 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.

7. 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?