Physics II
Unit 1: Projectiles
PE, KE, and Bungee Jumps

<u>The Bungee</u>: Make a bungee cord out of rubber bands. Suspend it from the ceiling (paper clips work nicely). When there's no load on it, the bottom of your bungee should hang no more than 1m below the ceiling. Your bungee should be capable of stretching all of the way to the floor without breaking.

<u>The Challenge</u>: You will be given a "free-fall distance." Given this free-fall distance, you must prepare an object with an appropriate mass, such that… When you attach the object to the end of your bungee and drop the object from 1 "free-fall distance" above the normal bottom point of your bungee, the object will reach its nadir at a point that is as close as possible to X cm from the ground. You will be given the distance X at the time of the competition.

<u>Formulas:</u>

F=ma, so **weight = mg**

W=fd

W=ΔE (In other words, if you do work, you lose energy; if you have work done on you, you gain energy. If the work is "conservative," no net energy is lost. *I'm not sure that saying W= ΔE is truly proper. It would be a good idea to read what the book has to say about the "work-energy principle.".)*

<u>One way to meet the challenge:</u>

1. Calibrate your bungee.
   a. Stretch your bungee a few times, to try to get it to some sort of equilibrium with regard to its elastic force. You don't want to calibrate it and then realize that the process of calibration stretched it out.
   b. Record the mass required to stretch your bungee to a variety of lengths.. You might want to hang a string to the "zero point" of your bungee. Make a table of mass of weights versus stretch distance.
2. Re-create your table in Excel. Use the template given to you, if there is one. Include the following components:
   a. Create a column for "force due to weights." Remember, F=ma, so to get the force due to your weights, multiply their masses<u>, in kg</u>, by 9.8m/s^2.
   b. Determine the work done in stretching the bungee to each length. Think of your bungee stretching in intervals. Your first stretching interval is the interval between 0m and the first distance to which your bungee stretched when you added weights. Determine the work done in each stretching interval.
      i. Create a column for work done on bungee during last interval → W=Fd. Or W = (average force)(interval length). In calculating work, assume that the stretching force (due to weights) during the interval is the average of the forces at the beginning and end of the interval.
      ii. Create a column for total work done on bungee through last interval. This is the sum of the work done during all of the intervals up to this point.
   c. Create a graph of "total work done on bungee" vs. "distance stretched." Remember, the independent variable should go on the X axis.

d. Now add the bungee jumper.
   i. On the same spreadsheet, create individual cells for "mass of jumper" and "free-fall height."
   ii. Set up a new column for "PE released by jumper." Assuming that the jumper jumps from the "free-fall distance" above the point where the bungee starts stretching, this row or column should calculate the PE released by the jumper at each "stretch distance" of the bungee.

e. Add your bungee jumper's released PE to the graph.
   i. Click on the graph. The open up "source data."
   ii. Click on the "series" tab. Then add a series – choose the values for the jumper's released PE for Y values. For the X values, choose the same "distance stretched" range that you chose in step c, above.

3. Find the bungee jumper's nadir (low point). This is the point where the jumper has no more kinetic energy; it has all been transferred to the bungee. At the jumper's nadir, the PE stored in the bungee should equal the PE released by the jumper. In other words, the point on your graph where the two curves intersect should give you the nadir.
4. Now, for any jumper mass and free-fall height, you can calculate the jumper's nadir. You can also work backward to get either the right mass for a given free-fall height and nadir…
5. Practice. See how accurately you can predict either required mass, required free-fall distance, or resultant stretch distance.

To Do:

- Set your graph up so that it shows you the solution to this problem. Then **print or e-mail the graph and solution to Mr. Stapleton** → What mass should a jumper have in order to reach its nadir at 1m from your bungee's zero stretch point? Assume that the jumper "jumps" from 0.3m above the zero stretch point.
- **Just think about this next one; you don't have to turn anything in.**

  Predicting bungee jumping drops seems like it should work in reverse, but it doesn't. Using your graph, you're able to determine how far the jumper will fall before bouncing back. But if you stretch a jumper downward to its predicted nadir, and then you let go, the jumper will not shoot up to the zero stretch point. **Why does this spreadsheet only work for dropping distances, and not for predicting the heights reached by masses that are being shot upward?**