Work and Energy Simulation Lab Worksheet

Name________________________

Group member names____________________________________

This sheet is the lab document your TA will use to score your lab. It is to be turned in at the end of lab. To receive full credit you must use complete sentences and explain your reasoning clearly.

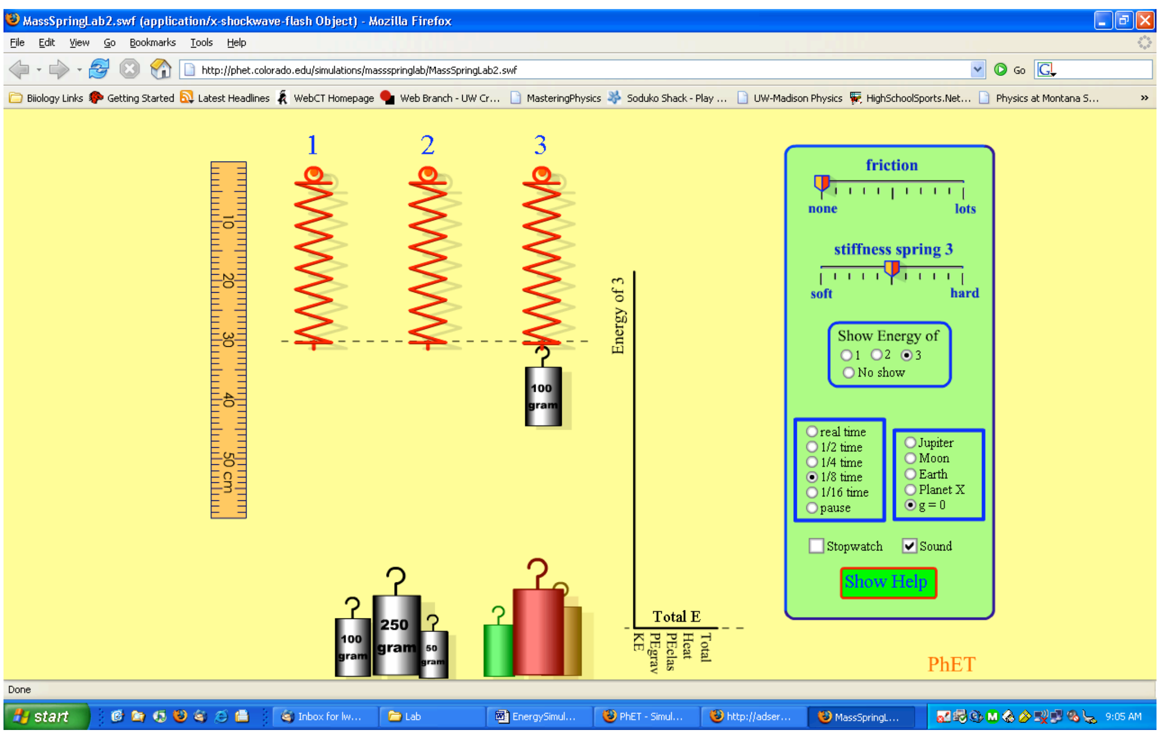
Be sure to read Chapter 11 (Work) in Knight before attempting this lab.

Go to the link, http://phet.colorado.edu, in a browser and click on the *Go to the simulations* button. Open *Work, Energy, and Power* on the left. This lab uses three of the simulations on this page, *Masses and Springs*, *Energy Skate Park*, and *The Ramp*.

I. Masses and Springs:

After opening the simulation *Masses and Springs* spend some time playing to become familiar with the various options and settings before attempting to answer the questions below. Please do take the time to let everyone spend at least five minutes at the computer at this stage. When you all know how to run the simulation you will be directed to the particular settings for each part below.

Settings for this part are shown below.



Note that *g* is set to zero, time is slowed to 1/8 time, and the friction is turned to 0 for now. With g = 0 this simulation behaves exactly like a ***horizontal*** mass-spring system with gravity turned on. Friction is then interpreted as between the mass and the surface on which it slides.

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1) Pull the mass down and hold it in place. You are "doing Work on the system" as you stretch the spring.

   a) What happens to the Mechanical Energy, *E*, of the system as you *stretch* the spring away from equilibrium? (increase, decrease, or stay the same) Mechanical energy, *E*, is *defined* as *K* + *U*.

   b) What happens to the Mechanical Energy of the system as you *compress* the spring away from equilibrium? (increase, decrease, or stay the same) This happens when you push the mass toward the top of the screen.

   c) Compare the Work done on the system when compressing the spring to the Work done on the system when stretching the spring with the questions below.

      i) Do both actions change the energy of the system in the same way or opposite ways? (both increase *E*, both decrease *E*, one increases *E* and the other decreases *E*)

      ii) What about the size of the change in energy? Does pushing the mass do more or less Work on the system than pulling it the same distance from equilibrium?

2) Now release the mass and watch the Energy Graph to answer the questions below.

   a) Describe how the Mechanical Energy, *E*, changes over time.

   b) Describe how the Kinetic Energy, *K*, of the mass changes over time.

   c) Describe how the Potential Energy, *U*, in the spring changes over time.

   d) Does the relationship $E = K + U$ hold at every instant of time?

3) Using the slider, add some friction to the system, start the mass moving and again use the energy graph to answer the questions below.

a) Describe how the Mechanical Energy, *E*, changes over time. *E* is mechanical energy and *Heat* is *not* mechanical energy. The red bar in the Total column can be misleading because it hints that thermal energy is mechanical energy.

b) Where does the Mechanical Energy go?

c) Compare the behavior of the Kinetic and Potential Energies here to the no-friction case. Describe similarities and differences.

d) Does the relationship $E = K + U$ hold at every instant of time?

e) For *E* to have changed there must have been some Work. What force is responsible for the Work that removes mechanical energy and turns it into thermal energy?

f) Should this Work be considered negative or positive? Be careful, the answer depends on whether we want the Work done on the SYSTEM by the ENVIRONMENT or the Work done on the ENVIRONMENT by the SYSTEM.

i) For "on the SYSTEM by the ENVIRONMENT" the Work is __________

ii) For "on the ENVIRONMENT by the SYSTEM" the Work is __________

g) How does the final Thermal Energy compare to the original Work applied?

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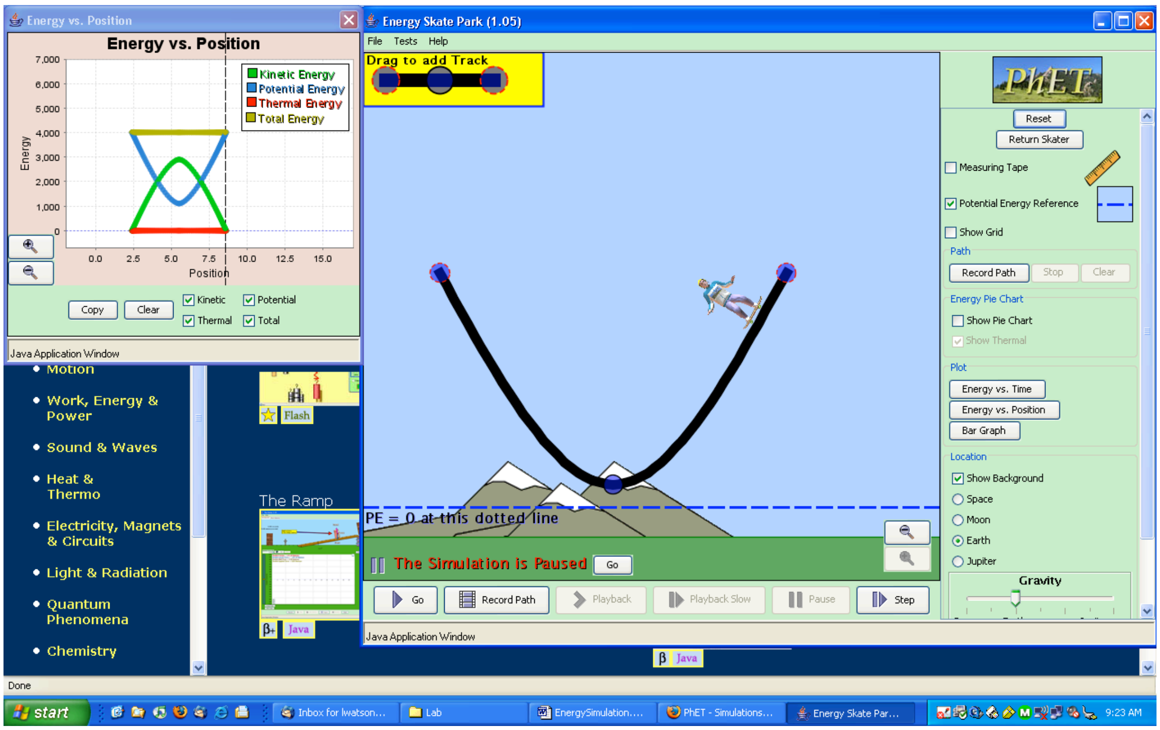
II. Energy Skate Park

After opening the simulation *Energy Skate Park* spend some time playing to become familiar with the various options and settings before attempting to answer the questions below. Please do take the time to let everyone spend at least five minutes at the computer at this stage. When you all know how to run the simulation you will be directed to the particular settings for each part below.

Settings for this part are shown below.



Note that PE Reference is turned on and the Energy vs. Position graph is displayed. You will need to move windows around to see everything.

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1) Start the simulation and answer the questions below.

   a) Describe how the Mechanical Energy, E, changes.

   b) Describe how the Kinetic Energy, K, changes.

   c) Describe how the Potential Energy, U, changes.

   d) Where do you have to place the PE = 0 reference so that PE = 0 when the skater is at the bottom of the ramp? Turn on *Record Path* for this part. The yellow dots mark the center of mass of the skater.

   e) How does the shape of the PE vs. Position plot compare to the shape of the ramp? Change the shape of the ramp and comment. *Record Path* can slow the simulation down so turn it off now.

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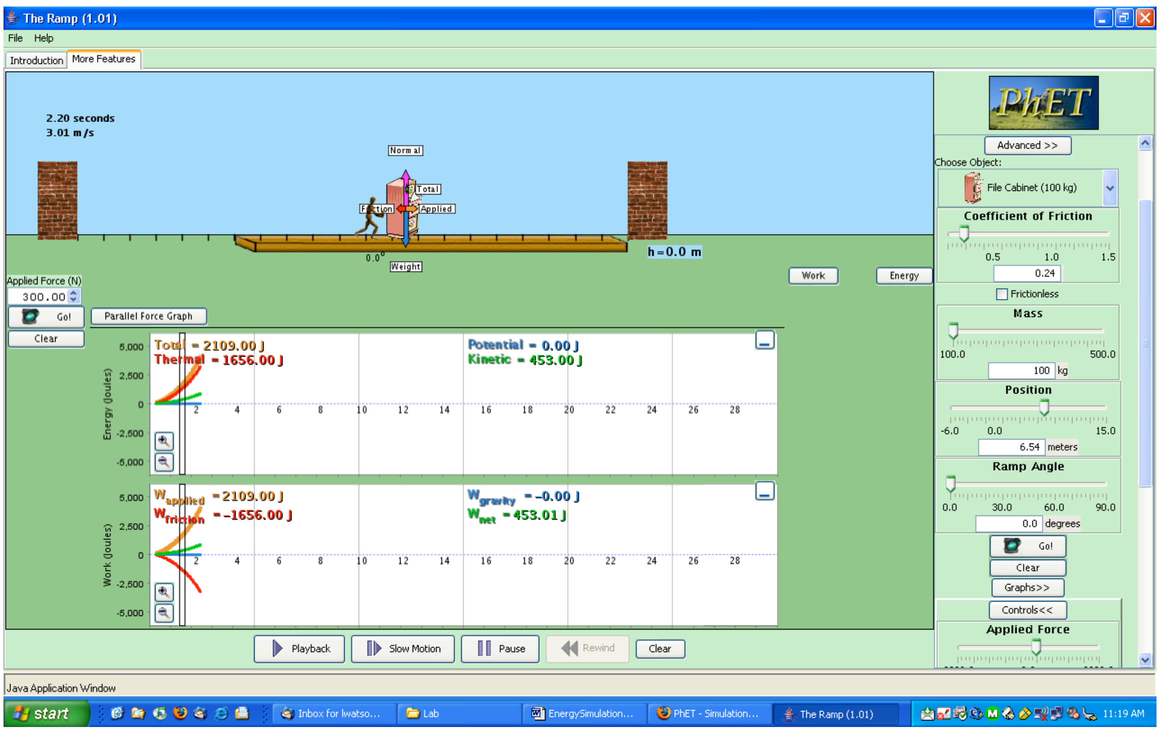
III: The Ramp

After opening the simulation *The Ramp* spend some time playing to become familiar with the various options and settings before attempting to answer the questions below. Please do take the time to let everyone spend at least five minutes at the computer at this stage. When you all know how to run the simulation you will be directed to the particular settings for each part below. This one has many options and you should open the "More Features" tab at the top left.

Settings for this part are shown below.



For this part the ramp is horizontal. Close the parallel force graph and open the Energy graph and the Work graph. Friction and the applied force are adjusted so that the plots are easy to read. You will need to zoom in to see the detail shown above.

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1) Use the Position Slider to set the file cabinet at the left end of the horizontal ramp and start the simulation. If the cabinet does not move either reduce friction or increase the Applied Force with the slider at lower right. The cabinet will accelerate along the ramp.

   a) Describe how the Mechanical Energy, *E*, changes over time. What plotted quantity equals *E*? Careful, the Total Energy plotted includes thermal energy.

   b) Describe how the Kinetic Energy, *K*, changes over time.

   c) Describe how the Potential Energy, *U*, of gravity changes over time.

   d) How is the net Work related to *E*? You should check that the relationship holds for all instants of time by dragging the tall box on the vertical axis left and right.

   e) How is the Work done by friction related to the thermal energy? Why is this Work negative? You should check that the relationship holds for all instants of time by dragging the tall box on the vertical axis left and right.

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2) Now repeat the experiment with the ramp at some angle. Adjust the controls and options to produce graphs that are easy to read. The cabinet will accelerate along the ramp.

   a) Describe how the Mechanical Energy, *E*, changes over time. Since *E* is not plotted explicitly, describe how you would use the graphs to find *E*.

   b) Describe how the Kinetic Energy, *K*, of the mass changes over time.

   c) Describe how the Potential Energy, *U*, of gravity changes over time.

   d) Does the net Work equal the sum of all the other Work terms? You should check that the relationship holds for all instants of time by dragging the tall box on the vertical axis left and right.

   e) Find a relationship between the in Mechanical Energy, *E*, and the various Work terms. You should check that the relationship holds for all instants of time by dragging the tall box on the vertical axis left and right.

   f) How is the net Work related to *E* now? Why is the Work done by gravity not counted when finding the Mechanical Energy, *E*, above?

   g) Is the Work done by friction still related to the thermal energy in the same way as before?