Phys 11A - Eiteneer

Lab: Energy Conservation

Online version

Note: this lab was originally written by Trish Loeblein, and modified by Professor Eiteneer

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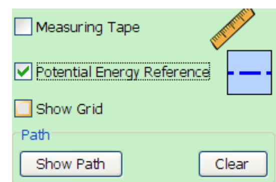
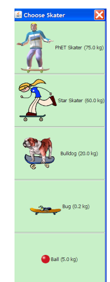
PURPOSE

The purpose of this lab is to experiment with different kinds of systems to see how/when energy conservation is applied. Practice using CoE to calculate the value of speed and energy from information about a different position.

Part I: Skate Park

1. Go to https://phet.colorado.edu/en/simulation/legacy/energy-skate-park, and download the simulation.
2. Play with the features shown to the right and the purple dot data to understand how to adjust them and what the data means. Figure out how to measure position **exactly**. Then, once you are comfortable with different parts, you can restart the simulation to perform the experiment. Note that changing the Skater only changes the mass.





3. Explain what changes and how when you move the PE reference line.

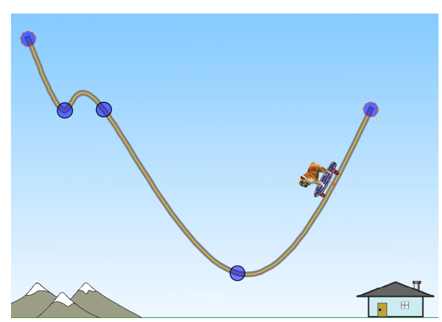
   When you move the PE reference line, potential energy and total energy both get affected. When raising the line, potential energy decreases and may eventually become negative. Total energy decreases and may also become negative.

4. Reset the simulation. Change the skater and explain if/what is different. Do any values change?

   Assuming that changing the skater changes the mass, then you would notice a change in total, kinetic, and potential energy.

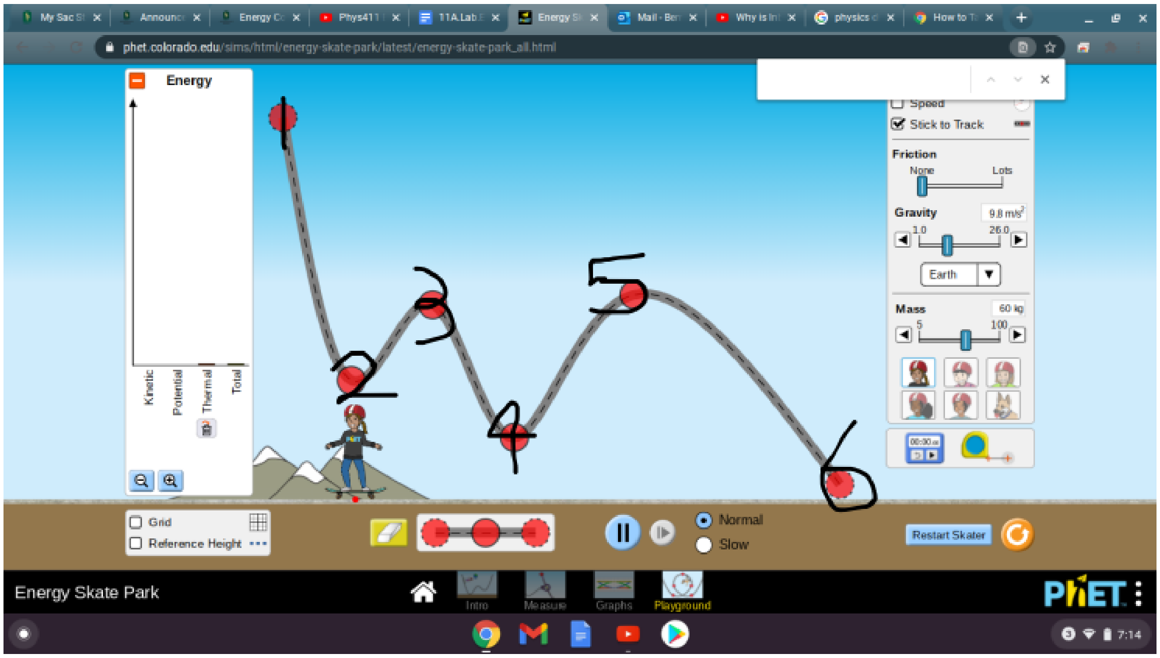
5. Create a "custom track" that includes a minimum of six different points as shown. The shape of your graph will vary, but make sure to include some "hills" and "valleys". You can also use one of the pre-built tracks (see "tracks") and modify it. Choose one of the Skaters and record the mass:

   m = _40_______________[kg]



6. Put the Skater on a track, Show Path and display the purple dot data. How could you predict the values for another place on the track? In your answer, describe what you would have to measure. Include the screen capture of your track. Label your points (1, 2, …)

   If you are trying to predict values for another place on the track, you could look at things like speed, mass, gravity, and height. Here, we would want to calculate potential energy and kinetic energy. Total energy is the combination of potential and kinetic energy.



7. Show **how** you would perform the calculations for each of the following values: K, U, E_{total}, speed.

K: Kinetic energy: $E_k = \frac{1}{2} * m * v^2$

U: Potential energy: $E_p = m * g * h$

E_{total}: Total energy = $E_p + E_k$

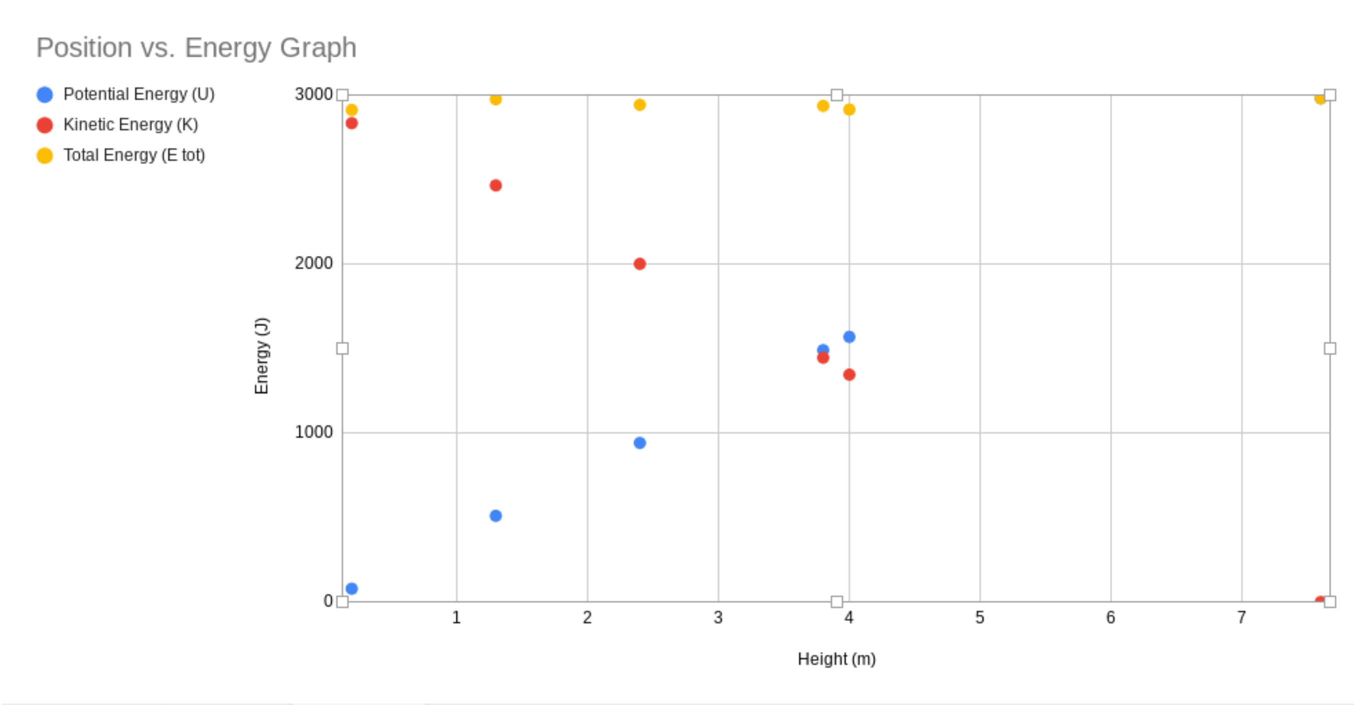
Speed = $\frac{distance}{time}$

Speed: $V_f = V_o + a * t$

8. Move your Skater to the highest point on the track, and give the Skater initial speed.
9. Let the Skate, and fill out the following table. Use the measuring tape included in the simulation to measure height **exactly**. Note: this may take a bit of practice – remember, you can always pause the simulation to make the measurement!

Point	Height [m]	U [J]	Speed [m/s]	K [J]	E_{tot} [J]
1	7.6 m	2979.2 J	0 m/s	0 J	2979.2 J
2	2.4 m	940.8 J	10 m/s	2000 J	2940.8 J
3	3.8 m	1489.6 J	8.5 m/s	1445 J	2934.6 J
4	1.3 m	509.6 J	11.1 m/s	2464.2 J	2973.8 J
5	4.0 m	1568 J	8.2 m/s	1344.8 J	2912.8 J
6	0.2 m	78.4 J	11.9 m/s	2832.2 J	2910.6 J

10. Make a graph of energies: energy on the vertical axis, height on the horizontal axis. On the same graph, plot K, U, E_{tot}. You can use Excel to graph, or do it by hand. If using Excel, use "scatterplot" option, **do not** use "connected dots". Make sure to label the graph, and the axes (with units). Include a screenshot of your graph, or attach it to this lab report.



11. Based on your graph, describe the trends/shapes of the three curves. Hint: you can also enable "graphs" in the simulation to help you answer this question.

    As we look at the skater's position, we notice that the skater's potential energy is positively correlated with height and that their kinetic energy increases as height decreases. This is to be expected as the skater's energy is being transferred from potential to kinetic while he/she descends down the ramp. The potential energy is just a sum of the two types of energies, so it should remain fairly consistent throughout the whole skater's travel. As we can see from the graph, that is the case. The slight loss and growth of total energy can be due to other factors like friction and heat, but the shape of the graph of total energy is still just about what we would expect.

12. Is there a place on your "custom track" where the Skater goes off track? **Explain why or why not**.

    There is a place on my custom track where the skater goes off track. It would mainly have to do with the height that my skater starts off on, which affects the skater's potential energy upon release.

13. Describe what you think will change in your calculations if you move the Skater to Jupiter.
    a. Describe what you would have to measure.

    We will likely have to measure mass, kinetic energy, potential energy, total energy, and speed again as the gravity on Jupiter is much stronger than on Earth.

    b. Show an example of your proposed calculations for each value: K, U, E_{total},, speed.

    The calculations would for the most part be the same, but we would now have to take this new gravity into consideration.

    Mass = 40kg (*Mass is the same everywhere, it's the weight that changes)

    Acceleration due to Jupiter's gravity: 24.8 m/s^2

    K: Kinetic energy: $E_k = \frac{1}{2} * m * v^2$

U: Potential energy: $E_p = m * g * h$

E_{total}: Total energy = $E_p + E_k$

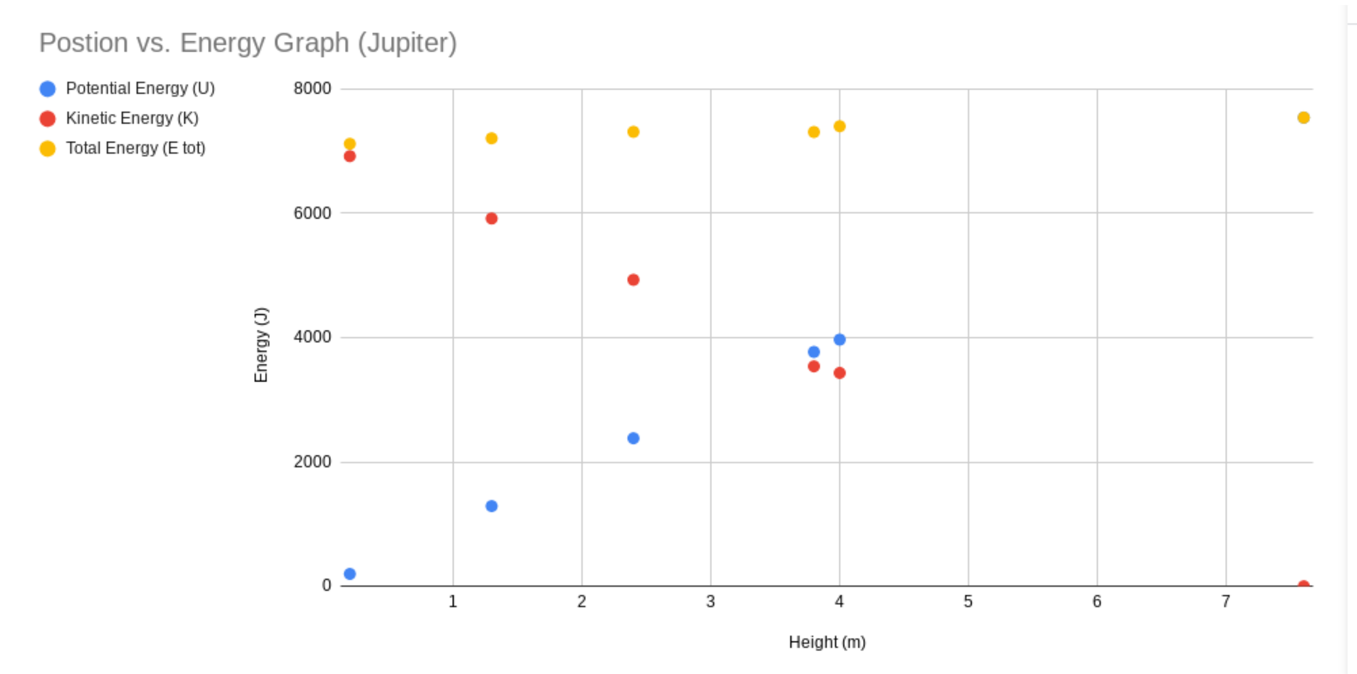
Speed: $V_f = V_o + a * t$

*With Jupiter's gravity, we should expect greater kinetic, potential, total energy, and speed.

c. Test your ideas and include a screen capture with the purple dot data shown to support your calculation.

Based on the data below, my assumption was correct.

Mass[kg]	Height [m]	U [J]	Speed [m/s]	K [J]	Etot [J]
40	7.6	7539.2	0	0	7539.2
	2.4	2380.8	15.7	4929.8	7310.6
	3.8	3769.6	13.3	3537.8	7307.4
	1.3	1289.6	17.2	5916.8	7206.4
	4	3968	13.1	3432.2	7400.2
	0.2	198.4	18.6	6919.2	7117.6



14. How do your calculations change if you take the Skater to the moon? Test your ideas and correct if necessary.

Again, our calculations should be similar, but with the moon's gravity being taken into consideration. We should notice lower kinetic, potential, and total energy as well as speed.

Mass[kg]	Height [m]	U [J]	Speed [m/s]	K [J]	Etot [J]
40	7.6	486.4	0	0	486.4
	2.4	153.6	4	320	473.6
	3.8	243.2	3.4	231.2	474.4
	1.3	83.2	4.4	387.2	470.4
	4	256	3.3	217.8	473.8
	0.2	12.8	4.8	460.8	473.6

*My hypothesis turned out to be correct.

Part II: Mass-Spring system

15. Go to https://phet.colorado.edu/en/simulation/masses-and-springs, and run or download the simulation. When you open the simulation, click on the Lab option.

16. Play with different features of the lab to understand how to adjust them and what the data means. Specifically, figure out how to change mass, spring constant, and damping. Figure out how to measure position **exactly** (hint: use a ruler included in the simulation!). Then, once you are comfortable with different parts, you can restart the simulation to perform the experiment.

17. Show **how** you would perform the calculations for each of the following values: K, U, E_{total}, speed.

K: Kinetic energy: $E_k = \frac{1}{2} * m * v^2$

U: Potential energy: Elastic: $PE_S = \frac{1}{2}K\Delta Y^2$ + Gravitational: $PE_G = m * g * h$

E_{total}: Total energy = $E_k + PE_S + PE_G$

Speed: $(V_f)^2 = (V_o)^2 + 2 * a * d$

18. Pick a value of mass, and make an assumption about the value of a spring constant and record both. Set the damping to zero for now.

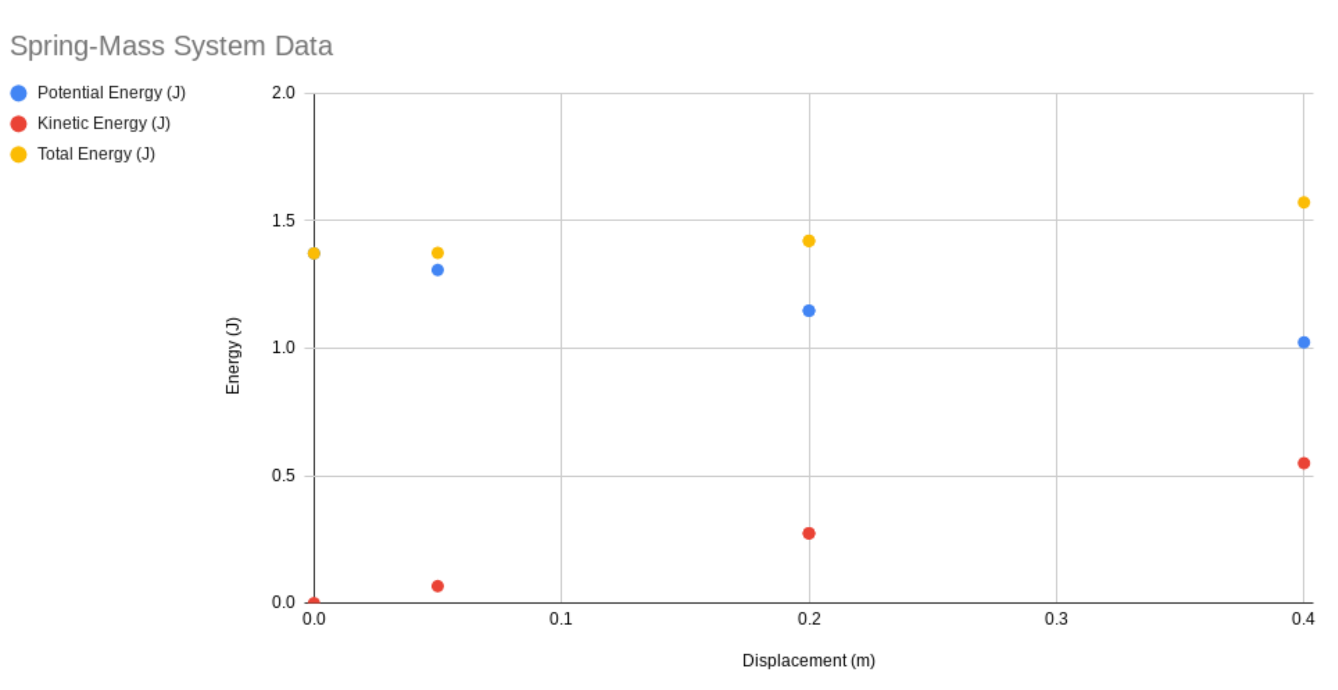
m = 0.14 [kg] k = 2.49 [N/m]

19. Set the system in motion, and fill out the following table. You may include more data points if you'd like. Use the ruler included in the simulation to measure displacement from equilibrium. Note: this may take a bit of practice – remember, you can always pause the simulation to make the measurement!

Point	Displacement [m]	U [J]	Speed [m/s]	K [J]	E_{tot} [J]
1	0 m	1.372 J	0 m/s	0 J	1.372 J
2	0.20 m	1.147 J	1.98 m/s	0.274 J	1.421 J
3	0.40 m	1.023 J	2.8 m/s	0.549 J	1.572 J
4	0.20 m	1.147 J	1.98 m/s	0.274 J	1.421 J
5	0.05 m	1.307 J	0.98 m/s	0.067 J	1.374 J

20. Make a graph of energies: energy on the vertical axis, displacement on the horizontal axis. On the same graph, plot K, U, E_{tot}. You can use Excel to graph, or do it by hand. If using Excel, use "scatterplot" option, **do not** use

"connected dots". Make sure to label the graph, and the axes (with units). Include a screenshot of your graph, or attach it to this lab report.



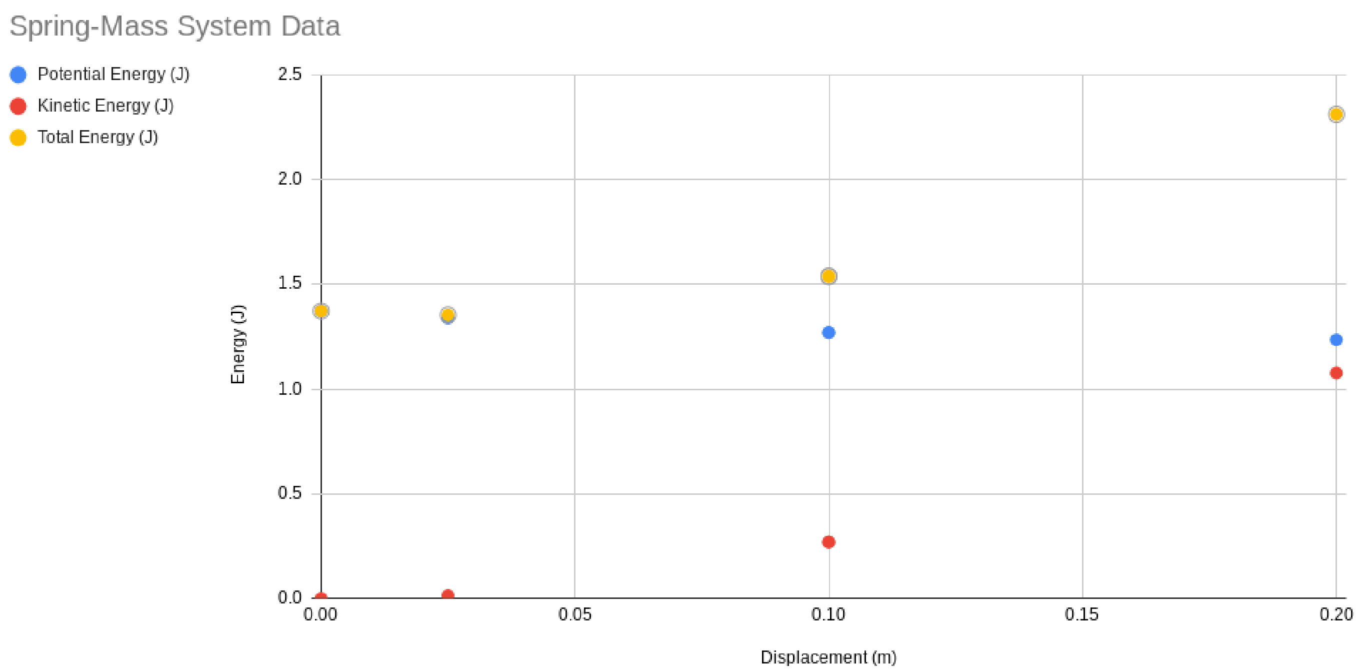
21. Based on your graph, describe the trends/shapes of the three curves. Hint: you can also use "graphs" in the simulation to help you answer this question.

    Based on the graph, potential energy gradually decreases over the displacement of the mass and kinetic energy gradually increases. Potential energy does not reach 0 and kinetic energy does not ever reach a maximum, which is expected as the mass is suspended by a spring that prevents it from reaching the floor. Total energy is fairly consistent.

22. Now pick some non-zero value of damping and describe qualitatively what happens. Try to include as much details as possible.

    Increasing the damping of the spring should reduce the displacement of the mass and somewhat increase the total energy of the system. I noticed that the potential and kinetic energy get closer to each other towards the end of the mass's displacement and that total energy seems to vary more wildly for some odd reason.
    *To be honest, I feel like I could do better, but I have so many things going on that I can't take the time to fully develop myself in each course. I feel bad about it, but at the end of the day, I just do what I can. Thank you.

Mass[kg]	Displacement [m]	U [J]	Speed [m/s]	K [J]	E tot [J]
0.14	0	1.372	0	0	1.372
	0.1	1.269	1.96	0.269	1.538
	0.2	1.235	3.92	1.076	2.311
	0.1	1.269	1.96	0.269	1.538
	0.025	1.339	0.45	0.014	1.353


Spring-Mass System Data
Potential Energy (J)
Kinetic Energy (J)
Total Energy (J)
Energy (J)
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.05
0.10
0.15
0.20
Displacement (m)