Energy Loss on Bounce Lab

Directions and Suggestions for Teacher

Purpose:

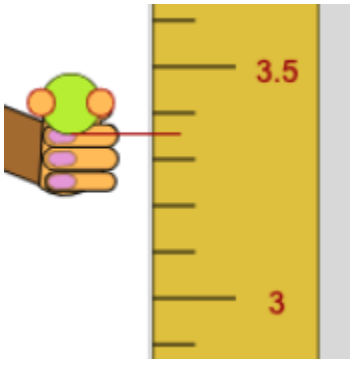
This lab is designed to give students experience with the idea of energy loss on a bounce. This lab will require students to know how to calculate the gravitational potential energy of an object. Students will measure the height of the object before and after a bounce and then find the loss of energy that occurred during the bounce. Once they have their graphs they will use the graph(s) to create a mathematical model and then use the model to make predictions.

Virtual Part:

(https://www.thephysicsaviary.com/Physics/Programs/Labs/EnergyLossWithPredictionLab/)

The virtual part of this lab could be done before students do a live version of the lab or if you have limited lab space you can have half the students working on the virtual part of the lab while the other half work on the live part of the lab.

Measuring Heights:



Students should measure the height of the ball off the ground. They will be measuring from the bottom of the ball to the floor. There is a thin red reference line that will follow the bottom of the ball to make it easier for the students to estimate the heights. Students should estimate the height to the nearest 0.01 meter.

Calculations:

Students should do their calculations of gravitational potential energy in Joules, so the mass of the ball that is given to them by the program should be converted into kg. All the equations they need to complete the lab are given to them on the right side of the program.

This lab was created by Frank McCulley for thephysicsaviary.com.

Working Through the Lab:

There are an infinite number of starting heights that the students could use in the virtual program. I would suggest students do at least five very different heights. It is a good practice to collect more data to have greater confidence in your results. The program will randomize the mass of the ball and the coefficient of restitution for these surfaces, so all students will get different results. Below is a sample of what potential data might look like.

Data:

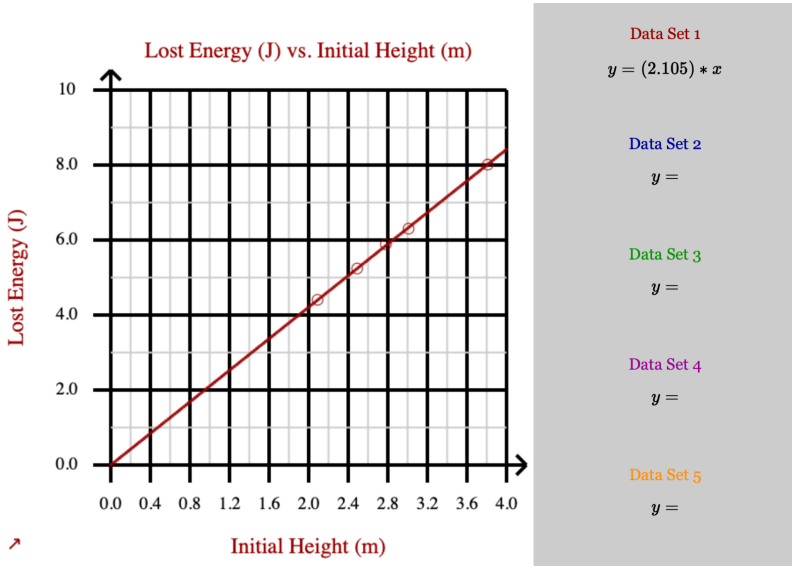
Starting Height (m)	Initial PEg (J)	Bounce Height (m)	Final PEg (J)	Lost PEg (J)	% PEg Lost
3.81	**14.47**	**1.70**	**6.46**	**8.01**	**55.4**
3.01	**11.43**	**1.35**	**5.13**	**6.30**	**55.2**
2.49	**9.46**	**1.11**	**4.22**	**5.24**	**55.4**
2.09	**7.94**	**0.93**	**3.53**	**4.41**	**55.5**
2.78	**10.56**	**1.23**	**4.67**	**5.89**	**55.8**

Graphing Data:

(https://www.thephysicsaviary.com/Physics/Programs/Tools/Graphing/)

Once students have finished collecting data, they should make two graphs. Both graphs will have the starting height (m) as the independent variable and should be placed on the x-axis. The first graph will have the raw energy lost on the y-axis and the second graph will have the percent of energy lost on the y-axis. The first graph should come out to be a proportional graph and the second one will come out as a no relationship graph.

I prefer always having the students transfer their graph onto their lab sheet by hand.



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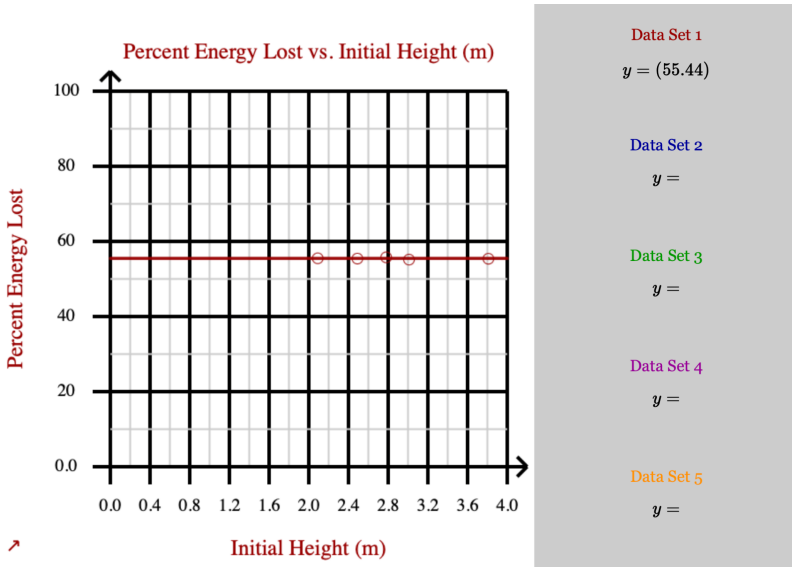


Equations:

For the first graph students get a proportional relationship between the variables. This indicates to them that a larger starting height will cause the ball to lose more energy. Doubling the starting height will cause the energy loss to double.

The equation for a proportional relationship is given below.

$$y = (\text{slope})*x$$

We want to continue to emphasize to them the idea that each of these letters has real physical significance. Looking at the axes, they should see that the y is the energy lost in Joules and the x is the starting height in meters. So the equation becomes:

$$\text{Lost PEg} = (\text{slope})*(\text{starting height})$$

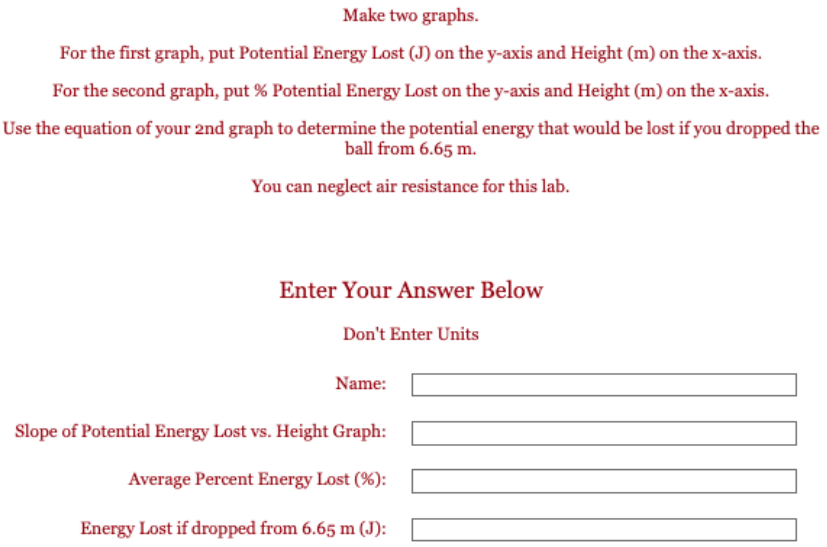
The slope of the graph will depend on the mass of the ball, the gravitational field of the planet, the elasticity of the ball and the type of surface it is bouncing off of.

The second graph will be a no relationship graph. This shows the students that as long as they don't change the nature of the ball or the surface it is bouncing off, the percent of energy lost will not change.

Checking their work:

Once the students have reached the point where they have graphed and created an equation, they will then be able to check their work. They should simply hit “Finished” on the program to be brought to a form they can fill out to see if they did everything correctly. Remind students that they all will be getting different answers and that they shouldn’t worry if their answers differ from those of their classmates.

Students will be entering the slope that they found when graphing the data for the first graph and the constant that they found for the second graph. They will then be told a starting height that they didn’t collect data for and they are to use their mathematical equation to predict the amount of energy that would be lost by that ball dropped from that height.



I would normally offer a small amount of extra credit added to the lab grade if they get all their answers correct. I would have them show me their completion certificate so I could record that they earned the extra credit. If a student doesn’t get everything correct, you can have them redo the lab by refreshing their page if time permits.

Live Part:

I always suggest a live lab counterpart to any virtual lab that you do with your students. For this lab I would bring in a bunch of different balls and let each lab group pick a ball that they will use for the experiment. Each group will try to drop their ball from at least five different starting heights. For each trial they will estimate as best they can the bounce height.

1. **Measuring Height**
    a. Taping two meters sticks to the wall will give students a two meter range over which to drop the ball.
    b. Blue painter's tape is the best kind of tape to use for this experiment.
    c. Make sure they measure to the bottom of the ball.
    d. Have them work as close to the wall as possible without letting the ball touch the wall.

2. **Finding Height After Bounce**
    a. Students can do this pretty accurately with just using their eyes, especially if they do a few trials from each height to hone in on the bounce height.
    b. I have had students record the bounce in slow motion on their phone and that gets great data also if you have time for them to do this for each of the trials.
    c. Make sure the students view or video the action as straight on as possible. Camera or eye level should be close to the height of the maximum bounce height.

Conclusion:

I personally like to have students write out a conclusion by hand after they are done with the entire lab (live part and virtual part). Some things you can have students include in the conclusion.

1. **Restatement of the purpose.**
    a. This is a great way to open the conclusion
    b. It helps to reinforce the reason we were doing the lab.
2. **Brief Summary of the steps**
    a. I don't want too much here but I do want students to transition from the purpose to the results with a sentence or two summary of the steps.
    b. This part of the conclusion should paint with a very broad brush what type of data we were collecting and what remained constant when collecting data.
3. **Results**
    a. I want students to clearly state what type of relationship existed between the two variables we were examining.
    b. I want them to clearly explain what this means in simple to understand terms.
    c. Basically, they will be making sense of the equation they have discovered in the lab.
4. **Error**
    a. They should talk about their percentage of error from the lab (you can have them do this for the live part or the virtual part or both).
    b. They should brainstorm at least one possible source of that error and how it can be minimized if they redid the lab.
5. **Limitations to the model**
    a. Whenever possible I want them to think about when the mathematical model for the lab would break down and no longer apply.
    b. For instance, with this lab, our model assumes that air resistance doesn't take energy away from the ball as the ball falls to the ground or when it is rising back up again. If the ball is too light or falls from too great a height, air resistance will make our predictions less accurate.

Going Further

If you have the time, you could challenge the students with the following types of things.

1. Use a few basketballs down in the gym to get the percent energy lost on a bounce. You can have them experiment with different pressures in the ball to see how the pressure in the ball affects the percent of energy lost on a bounce.

2. Have the students try bouncing tennis balls with different temperatures to see how the percent of energy loss changes with the temperature.

3. Have students try new versus old tennis balls.