

## **Energy of a Pendulum Lab**

### **Teacher's Guide**

**Topic:**

Work, Energy and Power

**The following information is provided to the student:**

**Question:**

What is the total amount of mechanical energy for a pendulum bob at three different locations along its path? How do the results compare to the expected results?

**Purpose:**

To determine the total amount of mechanical energy of a pendulum bob at three different positions along its trajectory and to compare the results to the expected results.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The data section should provide a graphic labeling the three locations in the trajectory of the bob which were analyzed. It should also include two tables of data - one for collected data and one for calculated data. The tables should have a row and column format; column headings should be clearly stated; units should be provided; work should be clearly shown for all calculated data. The Conclusion/Discussion should include a comparison of the total energy at three positions and a generalization about the principle which the data support. An error analysis should be conducted in which the expectations are discussed; the degree to which the data align with the expectations should be described. Averaging and percent differences should be used.

**Materials Required:**

Pendulum set up; photogate system; 200-g mass; meter stick.

**Description of Procedure:**

A 200-gram mass is hung from the end of a string; the other end of the string is connected to a pivot point or pendulum clamp in order to form a free-swinging pendulum. The pendulum is pulled back to a starting height; the height of the bob is measured. A photogate and an accessory gate are positioned along the path through which the bob will swing; one gate is positioned at the bottom of the trajectory and the other gate is roughly midway towards the bottom. The bob is carefully aimed and released from rest from the originally measured height and swings through the photogate and the accessory gate. The bob is caught and removed from the string after the first pass. Times are recorded and the width of the pendulum bob is recorded. The bob is then placed back on the string and positioned in the center of each gate; the height of the bob above the table at these two positions is measured. Heights, photogate times and the bob width are used in calculations of speed, kinetic energy, potential energy and total mechanical energy.

**Alternative Materials and Procedure:**

If photogates are at a minimum, it is convenient to have just a couple of setups. Train a couple of the best lab students on how to conduct the experiment. They can then run the trial with other lab groups, assisting them at quickly gathering their data. When lab groups aren't conducting their trial, they can be busy at their seats working on problems or other tasks.

## The Laboratory

### Safety Concern:

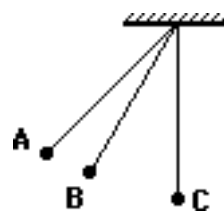
There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

### Suggestions, Precautions, Notes:

1. Students sometimes have difficulty with the readings of the photogates. The Gate setting (not the pendulum setting) should be used. The time recorded on the LCD panel of the photogate is the time for the bob to pass through the first gate. The memory switch can be used to determine the cumulative time for the bob to pass through both gates; subtraction is required to determine the time for the bob to pass through the second gate. Speeds are determined by dividing the bob width by the photogate times.
2. Caution students to be sure to release the bob from the originally measured position. A meter stick will have to be held vertically up from the table in order to locate that position.
3. Careful aiming of the pendulum bob is important; inform students that photogate timers cost more than iPods. And threaten them that they will have to hand over their iPod if they hit a photogate with the pendulum bob.
4. All measurements of height should be made from the table top to the center of mass of the pendulum bob.
5. The collection of data is rather cumbersome and holds many opportunities for failure. Providing further structure for the students' recording of data may help them to focus on the collection and analysis of data better. A structure similar to the following could be used:

Mass of Bob = \_\_\_\_\_ kg      Width of Bob = \_\_\_\_\_ m

Position	Height (m)	Photogate Time (s)	Speed (m/s)
A			
B			
C			



Position	Kinetic Energy ** (J)	Potential Energy ** (J)	Total Mech. Energy (J)
A			
B			
C			

\*\* = Show your work in the cells of the above table.

### Auxiliary Materials:

## The Laboratory

None

### Scoring Rubric:

<b>E8. Energy of a Pendulum Lab</b>	<b>Score</b>
<ul style="list-style-type: none"><li>___ Included, labeled and organized all parts of the lab report.</li><li>___ Data section includes a graphic clearly labeling the three locations along the trajectory which were analyzed. Included two tables of data - one for measured data and one for calculated data; column headings and units are clearly provided. Calculations are clearly shown and accurately performed. Measurements are reasonably accurate.</li><li>___ Conclusion/Discussion describes the energy at the three positions. Discussed expectations regarding the energy values and discussed the degree to which the expectations matched the results. Averaged all TME values and calculated percent differences for each trial based on the average; work is clearly shown and labeled for one of the trials. Discussion reveals understanding.</li></ul>	___/___

### Connections to The Physics Classroom Tutorial:

The following readings are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/energy/u5l2bb.cfm>

<http://www.physicsclassroom.com/Class/energy/u5l2bc.cfm>

### Connections to Minds on Physics Internet Modules:

Sublevels 7 and 8 of the Work and Energy module are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>