Determining the Kinetic Energy of a Pendulum

Introduction

Energy of motion is called **kinetic energy** (KE). An object's kinetic energy depends on its mass (m) and speed (v).

$$\mathbf{KE} = \frac{1}{2}mv^2$$

Energy of position is potential energy (PE), and it depends on mass, the acceleration due to gravity (g), and the height (h) of the object.

$$\mathbf{PE} = mgh$$

The sum of an object's kinetic and potential energies is called its **mechanical energy.**

If you have seen a grandfather clock, you are probably familiar with a pendulum, which consists of a weight that swings back and forth on a rope or string. As the weight, or bob, moves through its arc, its mechanical energy is constantly converted between potential energy and kinetic energy. The kinetic energy increases as the potential energy decreases, and vice versa. If there were no friction, the mechanical energy of the pendulum would remain constant, and the pendulum would continue to swing back and forth, reaching the same height each time. Friction causes the height of a pendulum's swing to slowly decrease until the pendulum eventually stops.

In this investigation, you will perform an experiment to determine when a swinging pendulum has the largest amount of kinetic energy.

Problem

When does a swinging pendulum have the most kinetic energy?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Controlling Variables** Identify the manipulated, responding, and controlled variables in this investigation.

   a. Manipulated variable

   _____

   b. Responding variable

   _____

   c. Controlled variables

   _____

   _____

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2. **Predicting** At what point in its arc do you expect the bob to have the most kinetic energy? At what point will it have the least kinetic energy? Explain your answers.

_____

_____

3. **Predicting** At what point in its arc do you expect the bob to have the most potential energy? At what point will it have the least potential energy? Explain your answers.

_____

_____

4. **Predicting** Will the block be moved farthest when the bob has the greatest potential energy or the greatest kinetic energy? Explain your answer.

_____

_____

5. **Formulating Hypotheses** State a hypothesis that this investigation can be used to test.

_____

_____

Materials *(per group)*

1-m string
fishing weight
flat, smooth board
4 identical bricks, approximately 8 cm in height
masking tape
lightweight wooden block
meter stick

Safety

Put on safety goggles. Be careful to stay out of the way of the swinging pendulum bob. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

1. Work with a classmate. Make a pendulum by tying the piece of string to the fishing weight. Hang the pendulum over the edge of a desk or table so that the weight, or bob, just clears a board placed on the floor beneath it. Tape the upper end of the string to the top of the desk or table, as shown in Figure 1.
2. Pull the bob slightly to the side and place a wooden block on the edge of the board, as shown, directly in the path of the pendulum's swing. Hold the bob in place next to the block while your lab partner measures the height of the bob above the floor. Record this value in the data table as the height of the bob at impact.

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3. Pull the bob up and to the side until it reaches a height of 30 cm above the floor. Release the bob, allowing it to swing down and strike the wooden block. In the data table, measure and record the distance that the block moved along the board.
4. Replace the block on the edge of the board and repeat Step 3 two more times, releasing the bob from the same point as in the first trial.
5. Place a brick beneath each end of the board. Move the board and bricks sideways so that the bob, when released, will just clear the near end of the board.

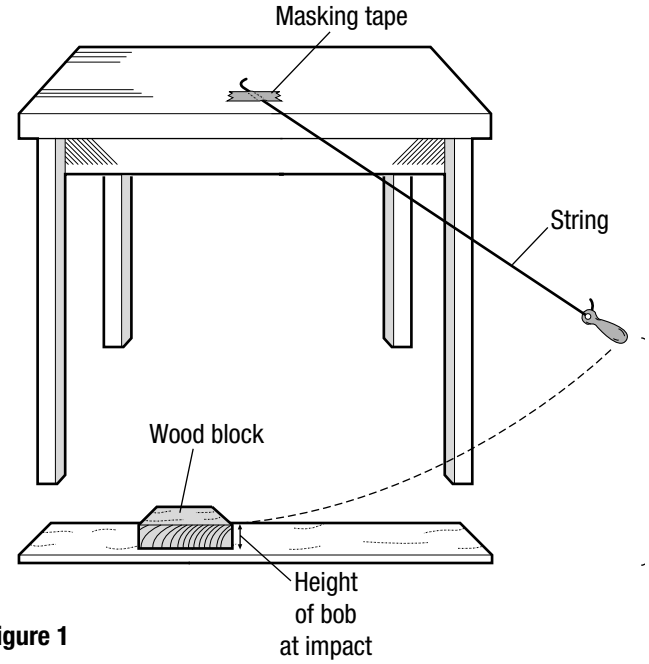

Figure 1

6. Place the block on the end of the board as before. Place the bob next to the block and have your partner measure its height above the floor. In the data table, record this as the height of the bob at impact.
7. Raise the bob 30 cm off the floor, as you did in Step 3. Release the bob and again measure and record in the data table the distance that the block moved along the board after impact.
8. Replace the block and repeat Step 7 two more times, releasing the bob from the same point as before.
9. Repeat Steps 5 through 8, this time adding a second brick under each end of the board and moving the board still closer to the release point.
10. Calculate the average distance that the block moved from each position. To do this, add the three distances you recorded and divide the total by 3. In the data table, record the average distances.

Observations

DATA TABLE

Number of Bricks Supporting the Board	Height of Bob at Impact (cm)	Distance Block Moved Along Board (cm)			
		Trial 1	Trial 2	Trial 3	Average
0					
2					
4					

Analysis and Conclusions

1. **Analyzing Data** How did the height of the bob at impact affect the distance that the block moved along the board?

2. **Drawing Conclusions** Based on your data, at what point in its swing do you think a pendulum has the greatest kinetic energy? Explain your answer.

3. **Evaluating and Revising** Did your data support or contradict your hypothesis? Explain your answer.

4. **Applying Concepts** Because of weathering, a rock on the edge of a cliff may become loose and fall. In terms of kinetic and potential energy, how is the rock at the edge of the cliff similar to a pendulum at the top of its arc?

Go Further

Draw five pictures, in sequence, showing a ball that has been thrown straight upward. Draw it going up (two pictures), at its highest point (one picture), and coming down (two pictures). In each picture, indicate which quantity, KE or PE, is greater. Also, indicate for each picture whether each kind of energy is in the process of increasing, decreasing, or staying the same.