# 32 Releasing Your Potential



## Purpose

To find quantitative relationships among height, speed, mass, kinetic energy, and potential energy

## Required Equipment/Supplies

pendulum apparatus as in Figure A
2 steel balls of different mass
graph paper or overhead transparencies
meterstick

## Optional Equipment/Supplies

computer with graphing software
photogate timing system

## Discussion

Drop two balls of different mass and they fall together. Tie them separately to two strings of the same length and they will swing together as pendulums. The speeds they achieve in falling or in swinging do not depend on their mass, but only on the vertical distance they have moved downward from rest. In this experiment, you will use a rigid pendulum (see Figure A) raised to a certain height. At the bottom of the pendulum's swing, a crossbar stops the pendulum, but the ball leaves the holder and keeps going.

How far downrange does the ball travel? The horizontal distance from the crossbar depends on *how fast* the ball is going and *how long* it remains in the air. How fast it is launched depends on *the launcher*. How long it remains in the air depends on how high it is above the floor or table.

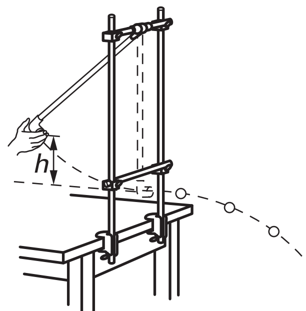


**Fig. A**

*Measure vertical height.*

## Procedure

**Step 1:** Devise an appropriate method for measuring the vertical height $h$ the pendulum ball falls. Record your method in the following space.

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*Launch ball with pendulum.*

**Step 2:** Raise the pendulum to the desired vertical height, using your finger to hold the ball in place. Take your finger away in such a manner that you do not push the pendulum up or down. Both the ball and pendulum swing down together, and the ball is launched upon impact with the crossbar. Practice your technique until you get consistent landings of the ball downrange.

*Measure the range.*

**Step 3:** When your results have become consistent, release the ball three times from the same height. Use a meterstick to measure the downrange distance for each trial. Repeat the experiment for six different heights. Record each average distance and height in Data Table A.

| Height | Distance | | | |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Average |
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**Data Table A**

*Calculate minimum launch speed.*

**Step 4:** Suppose the ball were attached to a lightweight string (as in a simple pendulum) that struck a razor mounted on the crossbar as shown in Figure A. If the ball is released from a sufficient height, its inertia will cause the string to be cut as it strikes the crossbar, projecting the ball horizontally. From the law of conservation of energy, the kinetic energy of the ball as it is launched from the low point of its swing is equal to the potential energy that it lost in swinging down, so $KE_{gained} = PE_{lost}$ or $\frac{1}{2}mv^2 = mgh$.

The launcher pictured in Figure A has its mass distributed along its length, so strictly speaking it isn't a *simple* pendulum. We'll see in Chapter 11 that it has less "rotational inertia" and swings a bit faster than if all its mass were concentrated at its bottom. For simplicity, we won't treat this complication here, and acknowledge that the speed calculated for a simple pendulum, $v = \sqrt{2gh}$, is a *lower limit*—the *minimum* launch speed. Record your computation of the minimum launch speed for each height from which the pendulum was released, in the second column of Data Table B.

| Height | Launch Speed Computed | Launch Speed as Measured by Photogate |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Data Table B**

**Step 5:** (Optional) Use a photogate timer to measure the launch speed of the ball at each of the six heights. Record your results in the third column of Data Table B.

**1.** How do the minimum and measured speeds of the ball compare?

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**Step 6:** In this step, you will investigate the relationship between the mass of the ball and its launch speed. Use a ball with a different mass, and release it from the same six heights as before. Record the downrange distances in Data Table C.

*Use balls of different mass.*

| Height | Distance | | | |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Average |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**Data Table C**

*Graph data.*

**Step 7:** You now have a tremendous amount of data. What does it mean? What is the pattern? You can often visualize a pattern by making a graph. Graph the pairs of variables suggested. You may want to graph other quantities instead. Use overhead transparencies or graph paper. Each member of your team should make one graph, and then all of you can pool your results. If a computer and data-plotting software are available, use them to make your graphs.

**Suggested graphs**

(a) Distance or range (vertical axis) vs. height from which the pendulum is released (horizontal axis) for the same mass
(b) Launch speed (vertical axis) vs. release height (horizontal axis) for the same mass
(c) Mass (vertical axis) vs. distance (horizontal axis) for the same height

If you are using data-plotting software, vary the powers of the $x$- and $y$-values until the graph is a straight line.

## Analysis

**2.** Describe what happens to the kinetic energy of the ball as it swings from the release height to the launch position.

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**3.** Describe what happens to the potential energy of the ball as it swings from the release height to the launch position.

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**4.** Describe what happens to the total energy of the ball as it swings from the release height to the launch position.

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## Going Further

Have your teacher assign you a specified distance downrange. Try to predict the angle from the vertical or height at which the pendulum must be released in order to score a bull's-eye.