Bowling Ball Pendulum

Conservation of Energy Demonstration

Introduction

Students may think it is foolish to place their face in front of a heavy, swinging bowling ball. However, this classic demonstration will clearly illustrate the conservation of energy principle.

Concepts

- Conservation of energy
- Potential energy
- Kinetic energy

Background

The *law of conservation of energy* states that energy cannot be created or destroyed, only converted between one form and another. When a pendulum is raised along its swinging path, work is done (energy is put into) to move the pendulum ball. This energy is stored in the pendulum ball as *potential energy*. When the pendulum is released, this stored energy is converted into energy of motion, or *kinetic energy*. The stored energy is converted completely into kinetic energy at the bottom of the swing. Therefore, at the very bottom of the swing the pendulum is moving at its fastest rate. As the pendulum swings up, the kinetic energy is converted back into potential energy. At the top of the arc, when the pendulum momentarily stops, all the kinetic energy has been converted into potential energy again. The potential energy at the top of this swing is identical to the potential energy the pendulum had before it was released. Therefore, the pendulum must rise to the same height it was before it was released. The pendulum will not rise higher than the original height because this would require more energy than the original potential energy can provide. The pendulum begins to fall again and the cycle repeats. Again, when the pendulum reaches its peak height and momentarily stops, the pendulum will be at the original starting height showing that the pendulum still has the same energy it had before it was released.

Materials (for each demonstration)

Ceiling support hook
Ceiling track
Cord, approximately 3.5 m
Lawn bowling ball with eyebolt, 4 kg
Meter stick
Step stool or ladder

Safety Precautions

The bowling ball is heavy. It may injure feet or damage the floor if dropped. Make sure the eyebolt holding the bowling ball is tied securely to the ceiling and that the ceiling can support the weight of the swinging bowling ball. The participant must keep his or her head still once the bowling ball is released. ***Do not push the ball when releasing.*** *Allow it to fall smoothly from fingertips.*

Preparation

1. Securely tie one end of the string to the eyebolt in the bowling ball.
2. Use a step stool or ladder to attach the ceiling support hook to the ceiling track near a secure, rigid anchor point in the ceiling. If an anchor point cannot be located, attach the ceiling support hook to the most rigid part of the ceiling track near crossing sections. *Note:* Ideally, when the bolwing ball is held by a volunteer at the maximum height of the swing, the
volunteer's head is against the wall.
3. Securely tie the free end of the cord to the ceiling hook. The bowling ball should hang approximately 30–50 cm above the floor.
4. Carefully lower the ball to a hanging position, making sure to monitor the stress on the ceiling track. If too much sagging or bowing occurs, or if the ceiling track does not appear stable, locate a more rigid section of ceiling track.
5. Once the ball is hanging securely, make sure the swinging path of the ball is clear of obstacles such as tables and chairs.
6. Perform a practice swing to make sure the ceiling track is strong enough to hold the swinging bowling ball, and that the ball swings in a straight line.

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Procedure

1. Ask for a "brave" student volunteer. (Alternately, the instructor may perform the demonstration.)
2. Position the student along the swing path of the pendulum.
3. Have the volunteer grab the ball and carefully walk backwards until the ball reaches the height of his or her nose.
4. Have the student remain as still as possible and have him hold the ball against the tip of his nose, making sure the string is taut so the ball will swing evenly when it is released. The student should hold the ball with his fingertips on the left and right side of the ball so that it can easily be released (see Figure 1).
5. Warn the student not to move his body, especially his head, forward or backward after releasing the ball. If the student's head rests against the wall it will be easier to keep it still.
6. With the ball held against the tip of the student's nose, have the student release the ball smoothly and quickly, without giving it any additional push, and without interrupting its swing.
7. The student should remain perfectly still as the ball swings through its arc and returns to the student. The student will want to duck or move out of the way of the ball during its return. Make sure the student remains perfectly still and that he does not move his head. *Note:* Be prepared to stop the ball if it appears the student pushed it or moved his head forward after releasing the ball.
8. The ball will return and will come very close to touching the tip of the student's nose, as long as the student has not moved his head.
9. After the demonstration, discuss with students the topic of conservation of energy. Relate the demonstration to energy topics such as potential energy and kinetic energy. When is the potential energy the highest during the pendulum's swing? When is the kinetic energy at its peak? Why does the pendulum gradually lose energy as it swings?

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS2 Motion and Stability: Forces and Interactions
  - PS2.A: Forces and Motion
  - PS2.B: Types of Interactions
- MS-PS3 Energy
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer

Disciplinary Core Ideas: High School
- HS-PS2 Motion and Stability: Forces and Interactions
  - PS2.A: Forces and Motion
  - PS2.B: Types of Interactions
- HS-PS3 Energy
  - PS3.A: Definitions of Energy
  - PS3.B: Conservation of Energy and Energy Transfer

Science and Engineering Practices
- Asking questions and defining problems
- Developing and using models

Crosscutting Concepts
- Patterns
- Cause and effect
- Systems and system models
- Energy and matter

Tips

- Ceiling track is standard in many schools. If ceilings are bare, a screw-hook or eyebolt may be securely screwed into the ceiling in place of the ceiling track hook. Make sure this is appropriate for your school before performing any alterations to the building. Ask a custodian or maintenance personnel for advice and help, if necessary.

- Large amplitude pendulum swings do not exhibit simple harmonic motion and, therefore, the returning bowling ball will come close to the nose, but may not touch it. Shorter pendulum string lengths, or shorter volunteers, will limit the amplitude of the pendulum and will make the swing more periodic. For small amplitudes, the ball will return to the nose. However, the high-swinging pendulum increases "fear" and makes the demonstration more dramatic, even if the ball does not return all the way to the tip of the nose.
- Use the pendulum to calculate the acceleration due to gravity. The equation for simple harmonic motion is as follows:

$$T = 2\pi \sqrt{\frac{L}{g}} \qquad \textit{Equation 1}$$

where T is equal to the period of the pendulum swing (measured in seconds), L is the length of the pendulum, and g is the acceleration due to gravity constant.

Bowling Ball Pendulum is available as a demonstration kit from Flinn Scientific, Inc.

Catalog No.	Description
AP6839	Bowling Ball Pendulum—Conservation of Energy Demonstration Kit
AP9330	Pulley cord, 9 m
AP5352	Ceiling Hooks, 2/pkg

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.