Bowling Ball Swing

Conservation of Energy

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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. The potential energy of an object that is raised above some reference height is calculated by multiplying the mass of the object by the acceleration due to gravity (9.81 m/s^2) and by the change in height of the object ($PE = mgh$). When the pendulum is released, this stored energy is converted into energy of motion, or kinetic energy. Kinetic energy is calculated by multiplying one-half the mass of the object by the square of its velocity ($KE = \frac{1}{2}mv^2$). 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.

During the demonstration, the bowling ball will swing along its arc and return to lightly touch the nose of the participant. The ball will not hit any harder or rise any higher than the original height because that requires more energy than the original potential energy of the pendulum.

Materials

Ceiling support hook (optional)

Ceiling track

Lawn bowling ball in mesh sack, 4 kg

Step stool or ladder

String, approximately 3.5 m

Safety Precautions

The bowling ball is heavy. It may injure feet or damage the floor if dropped. Make sure the mesh sack holding the bowling ball is tied securely to the ceiling and that the ceiling can support the weight of the swinging bowling ball. Check the condition of the mesh sack before using. 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. Tie one end of the string to the loop of netting located at the end of the mesh sack holding the bowling ball. Tie several knots to ensure the string and bowling ball are secure.
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 can not be located, attach the ceiling support hook to the most rigid part of the ceiling track near crossing sections.

3. Tie the free end of the string to the ceiling hook. Tie several knots to ensure the string is well secured to the ceiling hook. The bowling ball should hang approximately 30–50 cm (12–20 in.) 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.

Procedure

1. Ask for a "brave" student volunteer. (Alternately, the instructor can perform the demonstration in front of the class.)
2. Position the student along the swing path of the pendulum.
3. Have the student 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.
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.

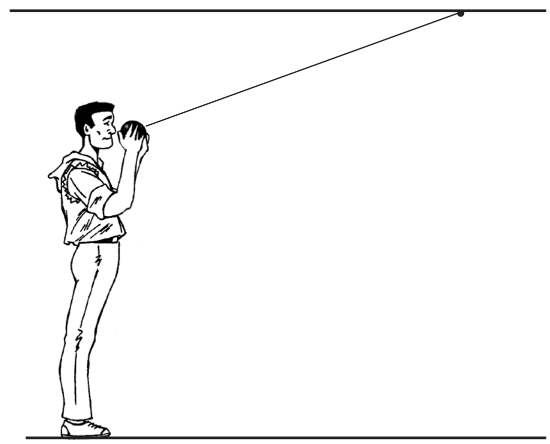

Figure 1.

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.
8. The ball will return and will come very close to touching the tip of the student's nose. The ball will not strike the student as long as his head has not moved.
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?

Disposal

The materials may be saved for future demonstrations.

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, fast-moving 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.
- For a more dramatic effect, perform the demonstration so that the volunteer must place his head against the wall. This will prevent the student from shifting his head back as the ball returns to his nose and will make it appear as if the participant has nowhere to go. Make sure that the student does not provide any additional push on the ball when it is released.

- This demonstration is a perfect way to introduce the concepts of the conservation of energy, potential energy and kinetic energy and damped motion. It also works well to reinforce the topics after they have been covered in class.
- This large pendulum is also a great device to illustrate damped motion. Or, make an extra-long pendulum and hang it from a high ceiling (such as in an auditorium) and create a Foucault pendulum. A Foucault pendulum swings in a constant plane, but as the Earth rotates, the arc appears to rotate (or precess). Use small amplitude swings to maintain simple harmonic motion and swing the pendulum in a North–South direction. It will take approximately 10–15 minutes for a noticable deflection.
- Use the pendulum to calculate the acceleration due to gravity. The equation for simple harmonic motion is as follows:

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

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. Refer to a physical science or physics textbook for more information on simple harmonic motion.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, understanding of motions and forces, transfer of energy
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, motions and forces, conservation of energy

Demonstration Worksheet Answers *(Student answers will vary.)*

1. Predict what will happen when the bowling ball is released from the tip of the participant's nose and then returns.

Student predictions will vary. Some students may predict that the bowling ball will hit the participant in the head. Others may predict that the ball will come right back to the same location.

2. Describe what happened during the pendulum's swing. Did the bowling ball return to the tip of the nose? Did the bowling ball rise higher or lower than its original height? Did the result support your prediction from Question 1?

After the ball was released, it made a long, "deep" swing, reaching a fast speed. At the opposite end of the arc from the participant, the ball came to a brief stop and then fell down again along its arc. It appeared to reach the same height as its released height. During the backswing the ball returned to the participant and came very close to the tip of the nose. The ball momentarily stopped again, and then swung through its arc, repeating the cycle.

Prediction results will vary.

3. At what location(s) along the pendulum's arc does the bowling ball have the most potential energy? At what location(s) does the bowling ball have the most kinetic energy?

The bowling ball has the most potential energy at the two high points of the swing (the starting position and the position it momentarily stops). The kinetic energy of the bowling ball is greatest at the very bottom of the swing. This is when the ball is traveling with the most speed.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Bowling Ball Swing* activity, presented by Lee Marek, is available in *Conservation of Energy*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Bowling Ball Swing* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Bowling Ball Pendulum—Conservation of Energy Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
P6839	Bowling Ball Pendulum—Conservation of Energy Demonstration Kit

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

Bowling Ball Swing Worksheet

1. Predict what will happen when the bowling ball is released from the tip of the participant's nose and then returns.

2. Describe what happened during the pendulum's swing. Did the bowling ball return to the tip of the nose? Did the bowling ball rise higher or lower than its original height? Did the result support your prediction from Question 1?

3. At what location(s) along the pendulum's arc does the bowling ball have the most potential energy? At what location(s) does the bowling ball have the most kinetic energy?