TRICK #3: The Floating Dollar Trick and The Rubber Band Reel

Teacher's Guide

Overview of the Trick:

Two "volunteers" are standing opposite one another in front of the magician. The magician borrows a dollar bill from one of them and crumples it up. He then opens his hand and the crumpled bill appears to float is air.

How the Trick Works:

(Do not reveal this to students until after they have proposed their own explanation for the trick.) Before performing the trick, the Magician enlists two "volunteers" to assist with the trick. One of them carries a hidden reel of fine plastic line. When they come to the front, the one with the reel attaches the end of the line to an object or his partner so that the line is reeled out in front of the Magician, as he diverts the audience's attention. When the Magician crumples the dollar bill, he actually folds it over the line as he crumples it, so that when he removes his hand the dollar appears to be floating.

Lesson Focus: **Conversion of Potential Energy to Kinetic Energy**

Lesson Synopsis: Students create a Thread Reel and duplicate the observed magic trick, as well as using the reel to create a new trick. In **What's Going On Here?**, they are introduced to the scientific concepts of potential and kinetic energy and apply the principle of converting potential energy in wound up rubber bands to kinetic energy by creating and altering the design of a "rubber band racer". As a **Math Connection**, they graph the relationship between number of turns and distance traveled.

Related National Science Education Standards:

Content Standard B (Physical Science):

As a result of their activities in grades 5-8, all students should develop an understanding of **Properties and Changes in Properties of Matter.**

Fundamental concepts and principles that underlie this standard include:

A substance has characteristic properties…

As a result of their activities in grades 5-8, all students should develop an understanding of **Motions and Forces**.

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Fundamental concepts and principles that underlie this standard include:

Energy … is associated with … mechanical motion… Energy is transferred in many ways.

Content Standard E (Science and Technology):

As a result of activities in grades 5-8, all students should develop **Abilities of Technological Design**, including the ability to **Design a Solution or Product** and to **Evaluate Completed Technological Designs and Products**.

Related Benchmarks from Benchmarks for Science Literacy:

Section 1B (Scientific Inquiry):

By the end of 8th grade, students should know that:

What people expect to observe affects what they actually do observe.

Section 3C (Issues in Technology):

By the end of 5th grade, students should know that:

Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems.

By the end of 8th grade, students should know that:

Once an invention exists, people are likely to think up ways of using it that were never imagined at first.

Section 4F (Motion):

"The more experiences the students can have in seeing the effect of reducing friction, the easier it will be to get them to imagine the friction-equals-zero case."

Section 8B (Materials and Manufacturing):

By the end of 8th grade, students should know that:

The choice of materials for a job depends on their properties and how they interact with other materials.

Section 8C (Energy Sources and Use):

By the end of 8th grade, students should know that:

Energy can change from one form to another…

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Section 9B (Symbolic Relationships):

By the end of 8th grade, students should know that:

Graphs can show a variety of possible relationships between two variables.

"At this level, students enjoy making and testing simple energy-conversion devices..."

Glossary:

- **potential energy** The energy a body has because of its position or condition. Potential energy is stored energy. Potential energy can be converted to kinetic energy.

- **kinetic energy** The energy a body has because it is moving.

- **friction** Friction occurs when surfaces rub against each other and interferes with the sliding of one surface over the other. Friction can be reduced by increasing the smoothness of the surfaces or by reducing the pressure between them.

Important Science Concepts:

1. A wound-up rubber band has potential energy because of its wound-up condition.
2. The potential energy of a wound-up rubber band is converted to kinetic energy as it unwinds.

Materials for Each Inquiry Team:

Materials for the Rubber Band Reel:

- Paper Towel Roll or Bathroom Tissue Roll
- 2 Rubber Bands
- Empty Plastic Spool from Thread
- Plastic Fishing Line
- Large Button

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Materials for Basic Spool Racer and Further Exploration:

- Large Thread Spool
- Rubber Band (at least same length as spool)
- "Guide Stick" (A pencil or pen may be used, or use a dowel or stick about three times as long as the diameter of the spool.)
- 2 Metal Washers (flat and smooth, with holes about as large as on the end of the spool)
- Masking Tape
- Paper Clips
- Assorted Sticks (dowels, skewers), Spools, Rubber Bands, and Metal Washers

Safety Precautions:

- Have students use goggles to protect their eyes against rubber bands breaking, if required by your school laboratory safety policy.

Procedure:

Engagement: Show the video of the **Floating Dollar Bill Trick.** Have students brainstorm in their **Inquiry Journals** possible explanations for the trick.

Exploration, Explanation, and Extension: see **Student Handout**

Evaluation:

1. Have teams demonstrate their functional reel and rubber band racer. (See **What's Going On Here?** handout.)

2. Have students design a new "magic trick" using the rubber band reel.

Ideas for Further Exploration:

1. See the suggested **Questions to Explore** on the **What's Going On Here?** handout.

2. Download the instructions for making a **Come-Back Can** (see **References**) and have students attempt to create one.

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Additional Background Information for Teachers:

This trick is one of numerous "levitation" tricks various Magicians do.

If students have difficulty getting their basic rubber band racer to "work", have them adjust the tension on the rubber band so that, when they wind up the rubber band and let go of the spool, the spool spins freely. The washers function to help reduce the friction between the stick and the spool.

References:

- **How to Make a Rubber Band Racer**, available online at http://webpages.marshall.edu/~bady/rick/elastic2.htm
- **Let 'em Roll**, **Newton's Apple Activity Page**, available online at http://www.ktca.org/newtons/9/slink.html
- **The Motorized Spool**, available online at http://www.iit.edu/~smile/ph9601.html
- **Come-Back Can**, available online at http://sprott.physics.wisc.edu/demobook/chapter1.htm

TRICK #3: The Floating Dollar Trick and The Rubber Band Reel

Student Handout

Materials for Each Inquiry Team:

- Paper Towel Roll or Bathroom Tissue Roll
- 2 Rubber Bands
- Empty Plastic Spool from Thread
- Plastic Fishing Line
- Large Button
- Fake Dollar Bill

Exploration:

Exploring the Visibility of Fishing Line:

1. Stretch a length of fishing line between two chairs.
2. Attach a piece of paper or an object to the line.
3. Have another team move toward or away from the line until they can just barely "make out" the presence of the line.

Creating a Rubber Band Reel:

1. First remove the paper from the ends of the plastic spool, revealing the channels running from one end to the other, around the center hole.
2. Cut a pair of notches at each end of the cardboard roll on one side and on the opposite side of the roll.
3. Cut out an oval smaller than the button on one side of the roll about midway between the ends.
4. Thread two rubber bands through two of the channels in the spool.
5. Tie a length of fishing line onto the spool and tape the ends in place so that the line cannot slip.
6. Wind the fishing line onto the spool.
7. Insert the spool into the cardboard roll and position it in the middle so that the end of the fishing line can be threaded out the oval opening and tied to the large button.

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Student Handout (continued)

8. Hook the ends of the rubber bands over the projections on the ends of the cardboard roll between the notches, fold the projections back and tape into place.
9. Pull on the button to unwind some of the line and then let go. What happens? (The line should pull out of the opening in the roll and then rewind. If it does not rewind completely, simply cut off the excess line and tie the new end to the button.)

Explanation:

Based on your observations, evaluate your proposed explanation of how the trick was done. You may want to revise your proposed explanation. Watch the video of the Magician revealing the secret of the trick.

Extension:

Another prop used by magicians is a "Magic Wand" with a built-in thread reel. Using your reel as a Magic Wand, create another magic trick. (**Hint:** Attach the button to a person and object and experiment with gently "waving" your wand in order to catch the line under a light-weight item such as a plastic flower to make it appear to float in the air.)

TRICK #3: What's Going On Here?

Student Handout

Tracing the Transfer of Energy

Hold a thick rubber band with both hands and rapidly move your hands apart and then together to make the rubber band stretch and relax. Quickly touch the rubber band to your lips. Do you feel warmth? Heat is a form of energy, so there must be energy being released, but where did the energy come from?

Energy exists in a variety of forms and can be transferred and changed from one form to another. In this case, your muscles used food energy to stretch the rubber band and some of this energy was transferred to the rubber band. As the rubber band regained its original shape, some of this transferred energy was released as heat.

The thread reel used energy in the wound-up rubber bands to rewind the fishing line onto the spool. Where did this energy come from? When the line was pulled out from the spool, some of the energy used in pulling was transferred to the rubber bands. Later, some of this transferred energy was transferred to the spool, which turned to rewind the line! (Think about it. Where did the energy for pulling the line out come from?)

Converting Potential Energy Into Kinetic Energy

As long as there was a steady pull on the line, the rubber bands remained stretched, but the reel did not move. The energy in the rubber bands was simply "stored". Stored energy is called **potential energy**. When stored energy is released, it may be released in various forms, depending on the situation. For example, a log contains stored energy. When we burn it, in what forms is this energy released?

In the case of the reel, the release of the stored energy caused the spool to rotate (move). Energy a body has because it is moving is called **kinetic energy**. Describing the entire process, we would say that the **potential energy** in the wound-up (and stretched) rubber bands was changed into (converted into) the **kinetic energy** needed to rewind the line.

Kinetic energy can be the result of an object's condition or its position. For example, when a model car is placed at the top of a ramp and released, it rolls down the ramp as its potential energy is converted to kinetic energy.

Rubber is a type of substance with the unusual property of being able to regain its shape once it is stretched. Let's explore using the potential energy in wound-up rubber bands to provide the kinetic energy to power a toy "racer" made with a thread spool!

TRICK #3: What's Going On Here? Student Handout (continued)

Materials for a Basic Spool Racer and for Inquiry:

- Large Thread Spool
- Rubber Band (at least same length as spool)
- "Guide Stick" (A pencil or pen may be used, or use a dowel or stick about three times as long as the diameter of the spool.)
- 2 Metal Washers (flat and smooth, with holes about as large as on the end of the spool)
- Masking Tape
- Paper Clips
- Assorted Sticks (dowels, skewers), Spools, Rubber Bands, and Metal Washers

How to Build a Basic Spool Racer:

1. Run a rubber band through the center hole in the thread spool. (Use a paper clip bent into a hook shape to pull it through if needed.)

2. Run the other end of the rubber band through 2 metal washers.

3. Insert a "guide" stick (pencil, dowel, etc.) through this end of the rubber band, so that one end does not project past the edge of the spool and the other sticks out about twice the length of the diameter of the spool.

4. Gently pull the other end of the rubber band so that the washers are against the spool. Then fold the other end of the rubber band over the end of the spool and tape in place.

5. Use the stick (pencil, dowel, etc.) to wind up the rubber band. (Test your racer by winding the stick and then letting go of the spool. It should spin. If it does not, try adjusting the tension of the rubber band.)

6. Wrap a rubber band around the spool near the end by the stick to help provide traction.

7. To operate your racer, pull the guide stick out so that only one end projects beyond the edge of the spool. Wind the stick 5 times and place the racer on a flat surface with the long end of the guide stick behind the racer. Release it! (The spool should turn as the racer moves forward, with the end of the guide stick sliding along on the surface. If it does not move, try winding more times.)

TRICK #3: What's Going On Here? Student Handout (continued)

Math Connection:

How does the number of times you turn the guide stick affect the distance traveled? To find out, measure and record the distance traveled after winding the stick 5 times. Now see what happens if you wind it 10 times, or 8 times, or 12 times. Plot all your data on a graph, in which the number of turns of the stick is on the X axis, and the distance is on the Y axis. Does winding twice as many times make your racer go twice as far? Does your graph look like that of other teams?

Engineering Challenge:

Experiment with and modify the design of your racer to create one that will be able to travel the farthest distance in the class race.

Questions to Explore:

1. Does the length of the guide stick affect performance?
2. Are 2 washers needed?
3. What if a shorter or longer or thicker rubber band is used?
4. Can you make a racer using an empty oatmeal box, an empty coffee can with a plastic snap-on lid, or a different type of spool?
5. Can you improve performance by increasing your racer's traction? (Traction means how well the spool "grips" the surface. Try adding wide rubber bands on the spool or wrapping your spool with various materials.)
6. How does starting the racer at the top of a ramp affect performance?
7. Can your racer climb a ramp?
8. If you leave your racer wound up over night (wind it and tape the stick in place), will it travel just as far? (Can the rubber band store energy over night?)

