ASME International

Engineering Magic

TRICK #2: Piercing a Balloon

Teacher's Guide

Overview of the Trick:

The Magician takes a long metal skewer and pushes it through one end of a balloon and out the other, without popping the balloon. He then removes the skewer and pops the balloon with it, proving it is not a fake balloon.

How the Trick Works:

(Do not reveal this to students until after they have explored the properties of the magic granules for themselves and have proposed their own explanation for the trick.)

The balloon is only partially inflated. The skewer is coated with oil and is inserted near the "nipple" end and out near the knot, two areas of the balloon that are relatively unstretched. As the skewer is removed, the oil helps to seal the holes, but the balloon does begin to leak, which would eventually become obvious to the audience. When the tip of the skewer is quickly pressed into the stretched side of the balloon, the balloon pops, "proving" that it is an ordinary balloon, and preventing the audience from observing an leakage of air.

Lesson Focus: **Properties of Elastomers (Elastic Polymers)**

Lesson Synopsis: Students explore the properties of the plastic polymer material used to make zippered food storage bags and the latex material used to make balloons and infer the scientific basis of the observed magic trick. In **What's Going On Here?**, they are introduced to elastic polymers. They explore the properties of man-made elastic polymers and use a rating scale to examine the effect of increased cross-linking on various properties, by means of graphs. They are then challenged to modify the recipes to create their own version of Goop and to compare its properties to the other versions.

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…

TRICK #2: Piercing a Balloon Teacher's Guide (continued)

Related Benchmarks from Benchmarks for Science Literacy:

Section IB (Scientific Inquiry):

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

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

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 on how they interact with other materials.

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.

Glossary:

- **polymers** Substances composed of long interconnected chains of repeated subunit
- **elastic polymers** Polymers capable of recovering their shape after being stretched. Also called **elastomers**.

Important Scientific Concepts:

1. Polymers consist of long chains of repeated subunits.
2. There are many types of polymers, with a variety of different properties.
3. The chains of polymers can be cross linked.
4. The amount of cross-linking can change a polymer's properties.

Materials for Each Inquiry Team:

- Goggles
- Small Zippered Food Storage Bags
- Water
- Small Cup of Cooking Oil
- Light-Colored Balloons (good quality)
- Bamboo Skewers (available at grocery stores)
- Plastic Wrap

TRICK #2: Piercing a Balloon Teacher's Guide (continued)

Materials for Making Goop:

- Elmer's glue
- Borax Powder (sold with laundry products in grocery stores)
- Paper towels
- Measuring spoons
- Water
- Small plastic cups
- Straws or spoons for stirring
- Tide powdered laundry detergent
- Liquid starch (not spray)

Safety Precautions:

- Persons with sensitivity to latex (a rare but serious allergy) should not work with latex balloons. Some persons are allergic to Borax. Remind students to exercise caution in working with sharp skewers and in blowing up balloons.

Procedure:

Engagement: Show the video of the **Piercing A Balloon Magic Trick.** Have students brainstorm in their **Inquiry Journals** possible explanations for the trick.

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

Evaluation:

1. Have students pierce samples of plastic wrap. Have them explain any differences in results as compared to those observed with the balloons and the food storage bags.

Ideas for Further Exploration:

Students might consider one or more of the following questions:

1. How many skewers can puncture one balloon without bursting it?

2. Can the trick be done without oiling the skewer?

3. How do different types of balloons (shapes, prices, colors) affect the results?

4. How do other polymer glues behave if used to make Goop?

TRICK #2: Piercing a Balloon Teacher's Guide (continued)

Additional Background Information:

The material used to make balloons consists of intertwined strands composed of long chains of molecules. This allows the material to stretch. When the skewer is pressed into and through the end of the balloon, the strands stretch but remain tightly stretched around the skewer, so no air leaks from the balloon.

The areas of the balloon near the "nipple" and near the knot are relatively un-stretched and allow the balloon to be skewered without bursting. Pigments added to color balloons interfere with the elasticity of the latex so darker-colored balloons are more likely to break when punctured with the skewer.

In the various Goop recipes, a non-cross-linked polymer (the glue) is combined with one or more cross-linker substances. The amount of cross-linking affects the properties of the resulting elastomer. Assigning a ranking to the various versions of Goop allows a quantification of the property so that the results can be graphed. Students should examine graphs for patterns – does the stretchability increase, decrease, or remain unchanged as the amount of cross-linking increases?

References:

- **"You'll Get the Point",** adapted from **Operation Chemistry**, available online at http://unr.edu/homepage/crowther/opchem/balloon.html

- **Poke But Don't Soak**, ***Wonder*Net Activity**, **American Chemical Society**, available online at http://www.acs.org/wondernet/activities/past/polymers/poke.html

- **Goop to Go!**, ***Wonder*Net Activity**, **American Chemical Society**, available online at http://www.acs.org/wondernet/activities/past/polymers/goop.html

- **Party Polymer**, **National Plastics Center & Museum**, June 1999, available online at http://npcm.plastics.com/slimystuff6-99.html

- **Elastomers (Natural and Synthetic Rubber)**, **Encyclopedia Britannica**, available online at http://www.britannica.com/bcom/eb/article/printable/0/0,5722,114770,00.html

ASME International

Engineering Magic

TRICK #2: Piercing a Balloon

Student Handout

Materials for Each Inquiry Team:

- Zippered plastic bags
- Water
- Round Balloons (good quality)
- Small cup of Cooking Oil
- Goggles
- Ruler
- Bamboo Skewers (available at grocery stores)
  Permanent Fine Tip Markers

Exploration:

1. Fill a small zippered food storage bag with water.
2. Working over a sink or bucket, carefully push a sharpened pencil into the bag.
3. Observe the area of the bag around the pencil. What do you notice?
4. Push the pencil out the other side of the bag and note the results.
5. Gently pull the pencil out and note the results.
6. Take an un-inflated balloon and push a skewer through it.
7. Compare the appearance of the balloon around the skewer to your observations on the plastic bag.
8. Draw around a dime to create several circles of the same size on various areas of 2 un-inflated balloons.
9. Blow one of the balloons up about halfway and the second one fully.
10. Observe the surfaces of the two balloons, noting areas where the surface appears to be more stretched or less stretched by comparing the sizes of the circles.
11. Dip a skewer into the oil and gently twist it and push it through the un-inflated end of the partially blown up balloon.
12. Once you are able to insert an oiled skewer into the end of a balloon without bursting it, gently twist and push it out the other end, near the knot.
13. Gently remove the skewer and observe the balloon over a period of several minutes.
14. Try the trick using the fully inflated balloon.

TRICK #2: Piercing a Balloon Student Handout (continued)

Explanation:

Propose an explanation for why the balloon does not burst, even when the skewer is removed, and why using a partially inflated balloon makes it easier to do the trick. Then read **What's Going On Here?** to learn more about natural and synthetic rubber and similar substances called elastomers.

Extension:

Predict whether the trick can be done using a water balloon, instead of an air-filled balloon. Try it.

TRICK #2: What's Going On Here?
Student Handout

Properties of Elastic Polymers

Polymers (PAH-lee-mers) consist of long chains of repeating subunits. There are many kinds of polymers, with many different properties. Natural rubber is a type of polymer with interesting properties. The history of this important polymer dates back to before the discovery of the New World by Christopher Columbus!

When the bark of certain South American trees is damaged, a milky liquid called latex flows out. As the substance dries, it can be formed into simple objects. Archeological evidence indicates that, long before 1492, Aztecs used balls of this material in ceremonial games. In 1736, samples of the substance were sent to Europe. Some years later, the English scientist Joseph Priestley (the discoverer of oxygen), commented that the substance could be used to erase pencil marks by rubbing it on paper, leading to its becoming called "rubber". In 1876, seeds of South American rubber trees were sent to England. Seedlings raised there were shipped to Ceylon (now called Sri Lanka) and Singapore. Over time, rubber plantations were planted extensively in Asia, the current source of most natural rubber. Synthetic rubber was developed in the United States during World War II, after Japan cut off Asian sources of natural rubber.

Balloons are made by dipping molds into liquid latex. When you inflate a balloon, the areas of the balloon near the "nipple" and near the knot are relatively un-stretched, as you discovered by drawing circles on an un-inflated balloon. When the skewer is pressed into and through the end of the balloon, the strands of latex stretch but remain tight around the skewer, so no air leaks from the balloon. This allows the balloon to be skewered without bursting. Pigments added to color balloons interfere with the elasticity of the latex, so darker-colored balloons are more likely to break when punctured with the skewer.

What is the cause of the interesting properties of rubber? Rubber is a type of polymer in which the long chains of repeated subunits are cross-linked and are sort of tangled, like a plate of spaghetti. This allows the material to stretch and to recover its shape somewhat when released. This type of polymer is called an elastic polymer, or an elastomer for short. Chemists have created numerous other elastic polymers. Elastomers can have very different properties, which affect their uses, but they all have the ability to recover somewhat after being stretched.

The amount of cross-linking affects the properties of elastomers. To explore this effect, let's make and test several versions of an elastomer we'll call "Goop", using different amounts of glue (a non-cross-linked polymer) and of Borax (the cross-linker substance).

TRICK #2: What's Going On Here Student Handout (continued)

Exploring the Effects of Cross Linking on the Properties of Elastomers:

Materials for Basic Goop:

- Elmer's glue
- Borax powder
- Paper towels
- Measuring spoons
- Water
- Small plastic cups
- Straws or spoons for stirring

Basic Goop (Recipe #1):

- Elmer's glue
- Water
- Borax powder
- Food Coloring

1. Mix 1 tablespoon Borax in 1 cup of water and stir until dissolved.
2. Label 4 small cups #1, #2, #3, and #4.
3. Add 2 teaspoons of the Borax solution to cup #1.
4. Add 4 teaspoons of the Borax solution to cup #2.
5. Add 6 teaspoons of the Borax solution to cup #3.
6. Add 8 teaspoons of the Borax solution to cup #4.
7. Add a small drop of food coloring to each cup – a different color for each.
8. To make Goop, add 1 tablespoon of glue to a cup and stir until a glob forms. (Each team member should stir one cup.)

Comparing the Properties of Goop #1, Goop #2, Goop #3, and Goop #4:

1. Mix up Goop following the given recipes.
2. Compare the properties of the four polymers in terms of the following properties:
3. How well do they stretch? Rank them in terms of their "stretchability", with #1 being the least and #4 being the most stretchable.
4. How well do they bounce? Rank them in terms of their "bounce-ability", with #1 being the least and #4 being the most bounce-able.
5. How well can they be molded? Rank them in terms of their "mold-ability", with #1 being the least and #4 being the most moldable.
6. How well do they retain their shape? Form a ball and let it sit on the table for a few minutes. Rank them, with #1 being the flattest and #4 being the most rounded.

TRICK #2: Piercing a Balloon Student Handout (continued)

7. Create a series of graphs, listing the 4 polymers across the bottom of the graph (the X axis) and their ranking for stretchability, bounce-ability, mold-ability, or shape retention on the Y axis. What can you conclude about how cross-linking affects these properties?

Engineering Challenge:

Create your own polymer using the available ingredients and recipes by changing the quantities and combinations of the ingredients. Be prepared to share your recipe and demonstrate your polymer's properties.

Other Cross-linker Substances to Try:

- Tide powdered laundry detergent
- Liquid starch (not spray)

Goop Recipe #2:

- 1 teaspoon Elmer's glue
- 2-3 tablespoons of liquid starch

1. Measure out ingredients into two cups.
2. While stirring the glue, slowly add the starch just until a white glob forms.
3. Remove the glob and blot it on a paper towel.

Goop Recipe #3:

- 1 teaspoon of Elmer's glue
- 1 teaspoon of water
- 1 teaspoon Tide
- 1 tablespoon water

1. Mix the glue with the 1 teaspoon of water in one cup.
2. Mix the Tide with the 1 tablespoon of water in the other cup.
3. While stirring the glue-water mixture, slowly add the Tide solution just until a white glob forms.
4. Remove the glob and blot it on a paper towel.

