Is It Chemistry?

Introduction

An episode of a popular show portraits a scientist working in a Space Research lab. In one scene, the scientist is grinding chunks of rock using a mortar and a pestle. The pieces of rock are the suspected remains of an asteroid that landed on Earth a few days back.

In another scene, the scientist transfers the finely ground rock sample into a flask made of glass, and then pours a clear liquid that mixes with the powdered rock. Almost immediately gas bubbles form, and the mixture turns bright orange. The scientist is elated at these results because the rock samples may be authentic and extremely interesting after all!

It is decided that the chemical reaction between the rock powder and the clear liquid deserves more investigative work. But how can the scientist be sure that a chemical reaction really occurred? And first, what is a chemical reaction?

Figure 1. This photo shows a demonstration of the popular Elephant's Toothpaste chemical reaction. Notice the various colors, and the foam rising and spilling out of the flask containing the mixture of chemicals. How do chemists know that this is a chemical reaction?

In this investigation, you will learn about the signs that characterize a chemical reaction!

Concepts

- Chemical Change
- Physical Change
- Chemical Reaction
- Structure and Properties of Matter

Background

A chemical reaction changes the way in which atoms are bound to each other in a substance.

For example, imagine that two substances are mixed and a chemical reaction between them occurs. One substance is represented with the formula **AA** and the other is represented with the formula **BC**. When **AA** and **BC** react chemically, two new substances (or products) form: **AB** and **AC**.

Note that these two products (**AB** and **AC**) are not the same as the initial substances (**AA** and **BC**). This could be represented as follows:

$$\mathbf{AA + BC \rightarrow AB + AC}$$

In this example, the plus sign (+) indicates that **AA** and **BC** are combined or mixed, and the arrow represents that a chemical reaction occurs and produces **AB** and **AC**.

Chemical reactions happen all the time inside and outside living organisms, and pretty much everywhere in the universe. Chemists have identified thousands of chemical reactions and thanks to that we now know the most common signs that characterize chemical change. These signs include:

a. Gas formation (release of gas bubbles)

b. Color change

c. Odor production

d. Release of light/heat

e. Production of popping sounds

These signs are used to determine the likelihood that chemical change is involved. To determine with certainty if a chemical reaction is happening or has happened, chemists use specialized equipment and tests.

Substances can also experience *physical changes* and, contrary to *chemical* changes, physical changes don't alter the chemical composition of substances.

For example, when a block of dry ice—that is solidified carbon dioxide, or the gas you exhale during breathing—is left out at room temperature, it evaporates over time. The gas emanating from the dry ice is still carbon dioxide—nothing has changed in the chemical composition of the carbon dioxide, only its physical state changed from solid to gas.

In this investigation, you will learn to recognize some of the signs that accompany chemical reactions, and the difference between chemical and physical changes!

Experiment Overview

In this investigation, you will learn to recognize some of the signs that characterize chemical reactions, and the difference between chemical and physical transformations.

Materials

- Calcium chloride solution
- Hydrogen peroxide, 3%
- Sodium carbonate solution
- Sodium chloride
- Steel wool
- Vinegar
- Water, distilled
- Ice cube
- Marker, fine tip
- Paper towels
- Pipets, 4
- Scissors
- Scoop or spatula
- Small beaker, or watch glass
- Stirring rod, glass
- Test tubes, 6
- Test tube rack
- Thermometer (optional)

Pre-Lab Questions

1. Physical changes affect the form of a substance or material but not its chemical composition. Between the following two events (**a** and **b**), which one is a physical change and why?

   a. Evaporation of water from the ocean due to heat coming from the sun.

   b. Burning candle wax which releases gas, water vapor, heat, and light.

2. Chemical changes affect the chemical composition of a substance or material, that is the type and number of atoms present, or how they are bound to each other. Between the following two events (**a** and **b**), which one is most likely to be a chemical change and why?

    a. A sheet of iron metal is treated with acid to produce iron oxide.

    b. A piece of copper metal is cut into smaller pieces.

Safety Precautions

Please follow all laboratory safety guidelines. Wear safety goggles, gloves, and a lab coat or apron. Tie back long hair. Do not eat or drink anything in the lab. Handle sharp objects with caution. Wash hands thoroughly with soap and water before leaving the laboratory.

Hydrogen peroxide (3%) solution is an oxidizing agent that can cause skin and eye irritation. Vinegar and sodium carbonate solutions can also be irritating to skin and eyes. You must wear safety goggles and gloves while handling these solutions.

Procedure

Part A. Introductory Activity

Follow these steps to explore the difference between chemical changes and physical changes.

1. Place an ice cube inside a small beaker, or on a watch glass. Record any observations in **Table 1** after 5 min and 15 min.
2. Place three test tubes in the test tube rack and label them 1–3.
3. Use a pipet to transfer sodium carbonate solution to test tubes 1–3, filling each tube to about one third of its volume. **Note:** Do not use this pipet with any other solution besides sodium carbonate.
4. Check **Table 1** to find out which substance is to be added to each of the tubes prepared in step 2.
5. Add the required substance to test tube 1. Gently stir the test tube and record any observations in **Table 1**.
6. Repeat step 4 with the remaining three test tubes. Record all your observations in **Table 1**.**Table 1. Introductory Activity Results and Observations**

Sample	Substance to Add	Observations
Ice Cube	None	
Test Tube 1: Sodium Carbonate	20 Drops of Distilled Water	
Test Tube 2: Sodium Carbonate	20 Drops of Vinegar	
Test Tube 3: Sodium Carbonate	20 Drops of Calcium Chloride Solution	

Stop and reflect on the following information!

- The melting of the ice cube represents a physical change, or a change of state (solid to liquid) but the water that makes the ice cube is still water after it melts—there is no chemical change.

- Adding water to test tube 1 containing sodium carbonate solution is also a physical change in that water is mixing with the solution in the tube, and no chemical transformation is taking place. Ultimately, the test tube still contains water mixed with sodium carbonate.
- Test tubes 2 and 3 contain mixtures in which chemical reactions do take place. In test tube 2, sodium carbonate and vinegar react to form gas bubbles (carbon dioxide), sodium acetate (dissolved), and water. In test tube 3, sodium carbonate reacts with calcium chloride to form a solid (calcium carbonate) which deposits over time at the bottom of the tube, plus sodium chloride (dissolved).

Part B. Experimental Challenge

Congratulations! You can now recognize some of the typical signs that characterize a chemical reaction.

Now your challenge is to spot all the signs that may indicate chemical reaction or only physical change in the following experimental setup.

To determine if a chemical reaction has occurred, look carefully for any of the following signs:

a. Gas formation (release of gas bubbles)

b. Color change

c. Odor production

d. Release of light/heat

e. Production of popping sounds

Physical changes like solubilization (solid in liquid, or gas in liquid) or change of state (solid to liquid, liquid to gas, or the reverse of these changes) are typically not accompanied by any of the signs described above.

7. Place three clean test tubes in the test tube rack and label them 1–3.
8. Cut three steel wool pieces approximately 1 cm × 1 cm in size.
9. Use a pipet to fill about one third of test tubes 1 and 3 with 3% hydrogen peroxide.
10. Pour about half a teaspoon of sodium chloride (NaCl) into test tubes 2 and 3. Gently stir test tube 3.
11. Record any initial observations for test tubes 1–3 under “Initial Observations” in **Table 2**.
12. Add one piece of steel wool into each one of the three test tubes. Gently mix the contents of each test tube using a stirring rod (clean this rod between use in different tubes).

13. Record any observations in **Table 2** under “Final Observations”.

Table 2. Experimental Challenge

Test Tube	Initial Observations	Final Observations
1		
2		
3		

Post Lab Questions

1. Explain why the changes observed with the ice cube are only physical and not chemical.

2. Based on the results and observations from the Introductory Activity, what are some of the signs that a chemical reaction has taken place in any of the test tubes?

3. Were there any physical changes observed during any of the experiments performed in the Experimental Challenge section?

4. Based on the results and observations from the Experimental Challenge, which were the signs that chemical change(s) took place in any of the test tubes?

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Colorful Salting Out

Chemical Demonstration Kit

Introduction

Two immiscible colorless liquids are in a bottle. A green marker is added to the bottle and the contents shaken, dying the solutions inside. With the marker again removed the solutions are now observed to be yellow and blue. Give the bottle a shake and the solution turns back to green. The layers then slowly return to yellow and blue.

Concepts

- Chromatography
- Non-polar vs. polar
- Solutions
- Immiscibility

Materials

Isopropyl alcohol, reagent, 500 mL*
Sodium chloride, 100 g*
Water, distilled or deionized
Balance, 0.1 g precision
Bottle with cap, plastic, 1 L*
Forceps, large
Funnel
Graduated cylinder, 500 mL, 2
Green marker*

*Materials included in kit.

Safety Precautions

Isopropyl alcohol is a flammable liquid and a fire hazard. It is slightly toxic by ingestion and inhalation. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Follow all laboratory safety guidelines. Please review current Safety Data Sheets for additional safety, handling and disposal information.

Preparation

1 Add 90 g of sodium chloride to the bottle.
2. Add 400 mL of distilled or deionized water to the bottle.
3. Cap the bottle and shake until the sodium chloride is mostly dissolved.
4. Add 400 mL of isopropyl alcohol to the bottle.
5. Cap the bottle tightly and shake to thoroughly mix the solution. Caution: Pressure may build up while shaking. Slightly loosen the cap to relieve the pressure then tighten the cap again.

Procedure

1. Present the bottle to the students and allow them to write down initial observations, completing questions 1–4 on the Colorful Salting Out worksheet.
2. Uncap the bottle and add the marker.
3. Recap the bottle and shake vigorously.
4. Uncap the bottle and remove the marker before recapping it (you might find it useful to have forceps on hand to remove the marker).
5. Have the students write down their observations.
6. Shake the bottle vigorously to completely mix the two liquids and place it on the table.
7. Once again have students record their observations.

Disposal

The bottle may be reused for many years, although only the first group of students will get to see you adding the marker.

Tips

- This kit contains enough materials to create one demonstration bottle.
- The cap may be glued onto the bottle to prevent opening, spillage or tampering.

Discussion

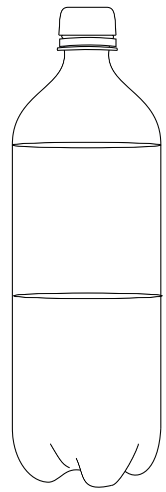
Water and isopropyl alcohol are miscible liquids that form strong hydrogen bonds. When sodium chloride is added to the solution, the ionic solid dissociates. The ions attract the water molecules and disrupt the hydrogen bonds between the water and isopropyl alcohol molecules. As two liquid layers separate, the isopropyl alcohol/water solution will appear on top of the more dense aqueous sodium chloride solution. The phenomenon is known as salting-out and is widely used to separate and purify organic compounds from aqueous mixtures. It is also used to precipitate proteins from aqueous cell extracts.

The pigments in the marker have different chemical structures and polarities. The polar blue pigment interacts positively with the polar sodium chloride solution and is primarily found in this region. Whereas, the non-polar yellow pigment is primarily found in the less polar isopropyl alcohol/water layer.

When the bottle is shaken, a nearly homogenous mixture of isopropyl alcohol and sodium chloride solution is formed, this type of homogeneous mixture is known as an emulsion. The emulsion recombines the two pigments and the original green color of the marker is observed. After the bottle is set down the emulsion starts to separate back into the two separate layers with the yellow layer on top and the blue layer on the bottom.

Answers to Discussion Questions *(Answers will vary.)*

1. Draw a diagram of the bottle and its contents as presented by your instructor.



2. Isopropyl alcohol and saturated sodium chloride solution have different densities. One has a density of 0.785 g/mL and the other 1.2 g/mL. How can you infer from your diagram which is denser?

   The more dense material will be on the bottom of the bottles. Materials with greater density sink to the bottom.

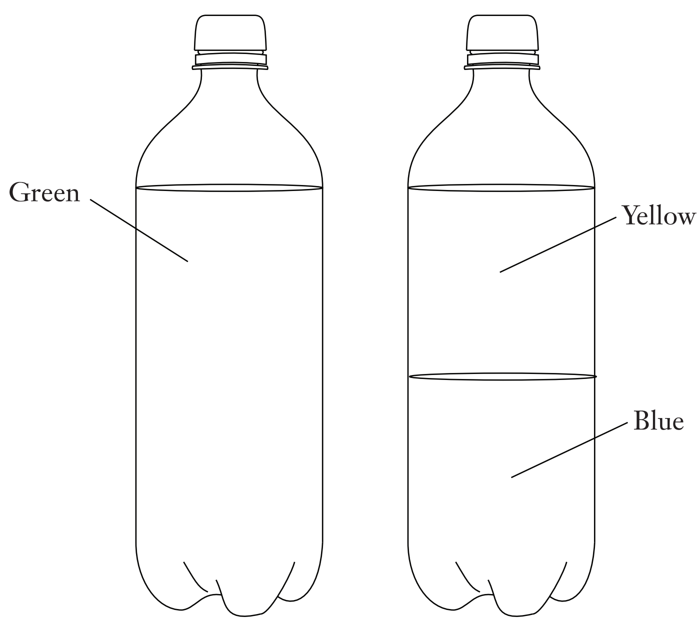
3. Predict what will happen after the marker is added to the bottle.

   When the marker is added to the bottle the color of the layers will change. The top layer will turn yellow, and the lower layer will turn blue.

4. Predict what will happen if the bottle is shaken and set back down.

   When the bottle is shaken the two colored layers will form and green emulsion. On standing they will separate back into the two different colored layers.

5. Draw diagrams of the bottle immediately after it was shaken and long after the bottle was shaken.

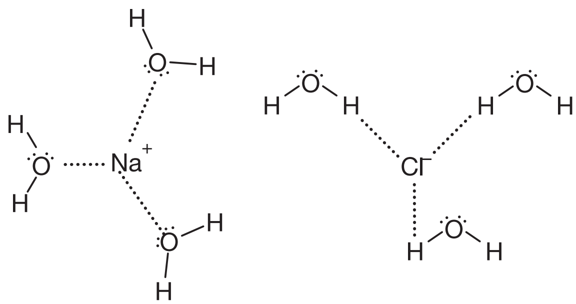


6. Write a possible explanation for what happened when the bottle was shaken and set back down.

   When the bottle was shaken, the isopropyl alcohol and sodium chloride solution mixed completely, making a temporary homogenous solution of uniform polarity. This combined the two colored pigments to give a green solution. On standing, the two layers separate and the pigments are again found in the layers that the result in the strongest intermolecular forces.

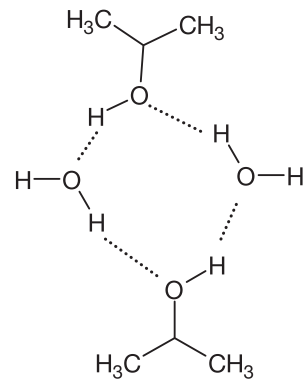
7 (*Optional*) Draw separate molecular diagrams of how sodium chloride and isopropyl alcohol would interact in water. Identify the types of intermolecular attractions within each diagram.

Sodium chloride in water



Ion–dipole interactions

Isopropyl alcohol in water



Hydrogen bonding interactions

8. (Optional) Based on previous answers, which colored pigment do you think is the most polar.

   The lower layer, containing the sodium chloride solution, is the more polar of the two. Since this layer is blue, and the upper layer yellow, it is reasonable to conclude that the blue pigment is more polar than the yellow.

Acknowledgment

Special thanks and acknowledgement to Kathryn Robles, Troy High School, MI for her assistance in the development of this demonstration.

The *Salting Out—Density Bottle Demonstration Kit* is available from Flinn Scientific, Inc.

Catalog No.	Description
AP9831	Colorful Salting Out—Chemical Demonstration kit
OB2138	Flinn Scientific Electronic Balance, 300 x 0.1-g

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

Name: ____________________________________

Colorful Salting Out

Discussion Questions

1. Draw a diagram of the bottle and its contents as presented by your instructor.

2. Isopropyl alcohol and saturated sodium chloride solution have different densities. One has a density of 0.785 g/mL and the other 1.2 g/mL. How can you infer from your diagram which is denser?

3. Predict what will happen after the marker is added to the bottle.

4. Predict what will happen if the bottle is shaken and set back down.

5. Draw diagrams of the bottle immediately after it was shaken and long after the bottle was shaken.

6. Write a possible explanation for what happened when the bottle was shaken and set back down.

7. (Optional) Draw separate molecular diagrams of how sodium chloride and isopropyl alcohol would interact in water. Identify the types of intermolecular attractions within each diagram.

8. (Optional) Based on your previous answers, which colored pigment do you think is the most polar.

Crazy about Chromatography

Introduction

Black is the lack of color–or is it? In this lab, you will separate three black ink mixtures from water-soluble, felt-tip pens or markers. Then, in the challenge activity you will produce a radial paper chromatography image.

Concepts

- Chromatography
- Separation of a mixture
- Physical properties

Background

Many common materials are made up of mixtures of compounds. Separating mixtures to determine the identity of one or more compounds has many practical applications in the fields of medicine, law enforcement, and manufacturing. It is often difficult to separate mixtures if the compounds are chemically similar. *Chromatography* is a technique used to identify and analyze components of a mixture.

Paper chromatography is a type of chromatography called adsorption chromatography. The paper acts as an *adsorbent,* a solid which can attract and stick with the components in a mixture (think of the word adhere). The solvent carries the materials to be separated through the adsorbent. In this lab, the solvent will be water.

The mixture to be separated is “spotted” onto the surface of the paper and water is then allowed to seep through the paper. As the components of the mixture dissolve in the water, they will travel up the paper at different rates depending on their physical properties. If one of the components in the mixture is more strongly attracted onto the paper than another, it will spend less time in solution and will move up the paper more slowly than the water. Components that are not strongly attracted onto the paper will spend more time in solution and will move up the paper at a faster rate. This separates the components and gives rise to different bands, depending on their physical attraction for the paper versus the solvent (water). If the components of the mixture are colored, the bands are easy to see.

Radial chromatography is a technique using a paper circle with a hole in the center. Ink is spotted onto the circle. A paper "wick" is inserted into the hole and then placed in a cup of water, making sure the paper circle does not come in direct contact with the water (Figure 1). The water seeps up the wick, then outward through the paper. The different pigments making up the ink mixtures will separate in a circular (radial) pattern. The resulting pattern is called a *chromatogram*.

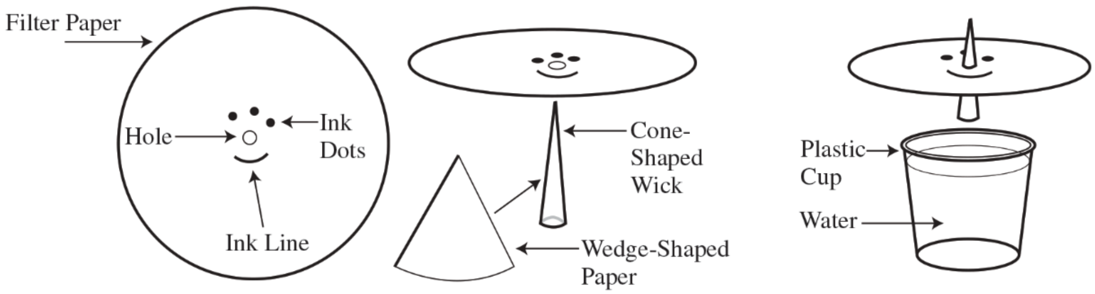


Figure 1. Radial Paper Chromatography

Experiment Overview

The purpose of this lab is to study the separation of mixtures by physical properties. In the introductory activity, students will investigate the ink of three black markers or pens. Then, in the challenge activity, students will produce a radial paper chromatography image based on their results from the introductory activity.

Materials

- Colored pencils (optional)
- Cups, plastic 30-mL, 2
- Cups, plastic 16 oz, 3
- Filter paper, 12.5 cm diameter, 4
- Graduated cylinder, 50-mL
- Markers and pens, black, water-soluble, various types, 3
- Paper clip (optional)
- Paper towels
- Pencil
- Ruler, metric
- Scissors
- Stapler
- Tape (optional)
- Water
- Wooden splints, 3

Pre-Lab Questions

1. Define the following three terms: chromatography, solvent, and adsorbent.

2. Draw a picture of the radial chromatography final set up and label all the parts.

3. What will be the adsorbent in this activity? What will be the solvent?

Safety Precautions

Although the materials in this activity are considered nonhazardous, please observe all normal laboratory safety guidelines. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Part A. Introductory Activity

1. Cut three strips of filter paper from one piece of filter paper, as shown below with the dotted lines in Figure 2.

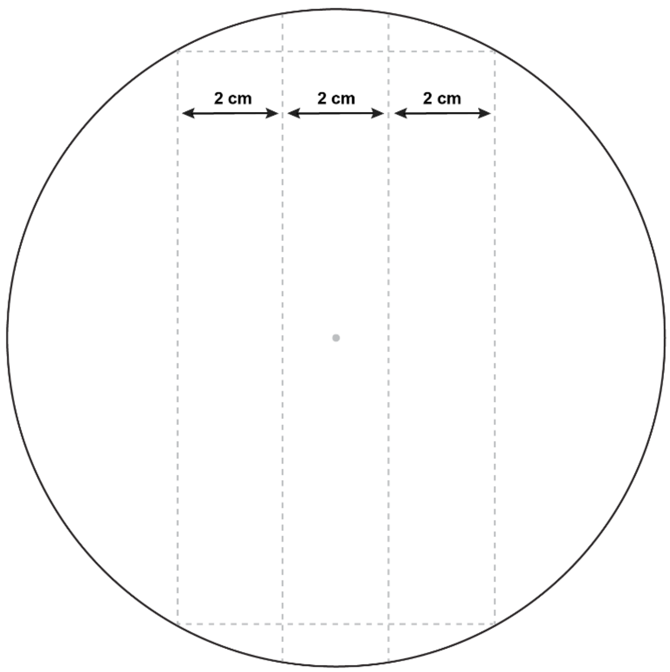


Figure 2. Cutting the Filter Paper Strips

2. Using a pencil, lightly draw a line across the width of each strip, 2 cm from one end (see Figure 3a).

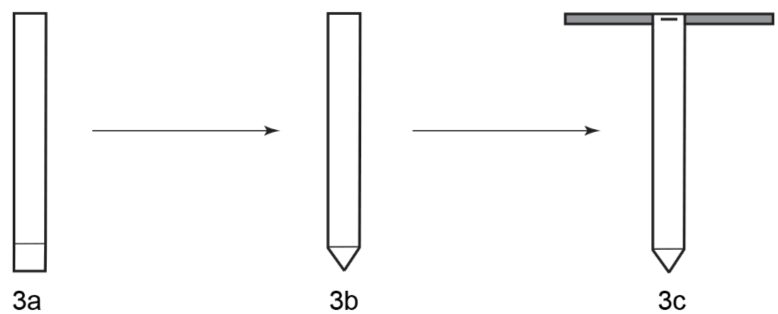


Figure 3.

3. Cut off the bottom corners of each strip to create a point, as shown in Figure 3b. Staple or tape the strip to a wooden splint as shown in Figure 3c. Repeat for all three strips.
4. Add 25 mL of water to each 16 oz. plastic cup.
5. Using a pen or marker, place a small dot on the center of the drawn line on one chromatography strip.
6. Using a pencil, label what pen or marker you used at the top of the strip or on the wooden splint.

7. Slowly lower one filter strip into the plastic cup. See Figure 4. The sample spot should remain above the solvent (the water). If it is not, your sample will dilute into the water. If the water is not high enough, remove the filter strip and add more water in 5 mL increments until the water touches the bottom point of the filter strip.

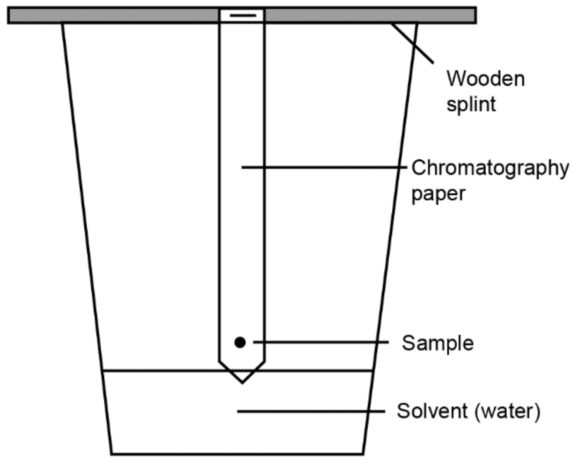


Figure 4.

8. Repeat steps 5-7 for two more different pens or markers (one pen/marker dot per strip).
9. Allow the filter strips to run until the water line reaches approximately 1 cm from the top of the paper (about 15-25 minutes).
10. Take pictures or sketch your results with colored pencils.
11. Share with at least two other groups to get the results of all eight markers.

Data Table 1.

Pen/Marker	Color(s) Observed	Photo or Sketch (with colored pencils)

Part B. Challenge Activity

12. Different designs and patterns can be made with radial chromatography. For example, see Figure 5 for two versions made with a variety of markers and pens.

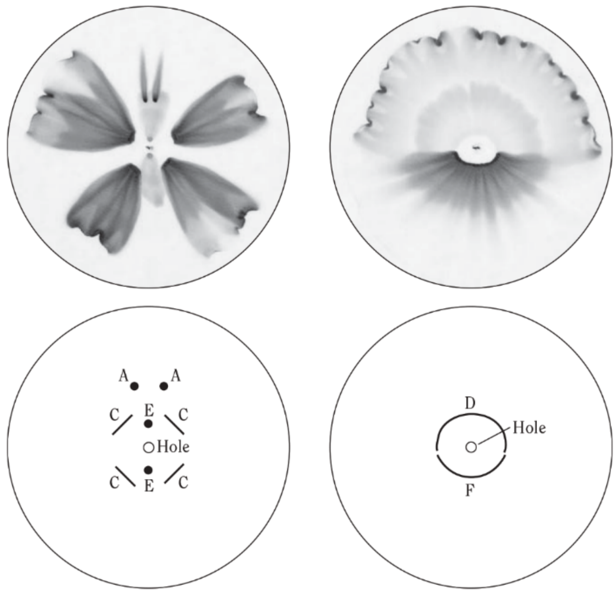


Figure 5.

13. The different letters, in Figure 5, correspond to different markers. Ink formulations are constantly changing, use what you discovered in Part A to decide what markers and pens to use to make your own artwork.
14. Your teacher also has some additional example artwork to reference for more ideas.
15. Discuss with your group and decide on two designs.
16. To make your radial chromatography designs follow the following steps:
    a. Obtain a piece of filter paper.
    b. Using a sharp pencil, paperclip, or pushpin, poke a small hole in the center of the filter paper.
    c. Fill a 30-mL plastic cup to within about 1 cm from the top with tap water.
    d. Starting at least 5 mm from the center hole, place a small but concentrated spot of ink from a water soluble marker or pen onto the paper. The “spot” may be a dot, a wedge, a short line, an arc, etc. See Figure 5 for an example.
    e. Obtain a wedge piece of paper from your teacher and roll up the filter paper wedge into a tight cone. Insert the cone-shaped “wick” into the hole in the center of the filter paper. See Figure 1 for reference.
    f. Set the prepared filter paper circle on top of the water-filled cup. When the water has advanced to within 1-2 cm of the outer edge of the filter paper (about 10-15 minutes), carefully lift the chromatography image and set it on a paper towel to dry.

17. Take a photo or sketch your artwork below. Use colored pencils, if desired.

18. If time allows, try making another radial chromatograph! Your group has enough supplies to make a total of three designs for this challenge activity.

Post Lab Questions

1. List the brand of each pen tested in this activity and record the colors observed. For each pen, list the colors (pigments) from least mobile to most mobile. The least mobile pigments will be the ones closest to the dots or lines made – these pigments have the greatest attraction to the paper. The most mobile will be closest to the outside or top edge of the papers.

2. Why does an ink separate into different pigment bands?

3. Do any of the pens or markers appear to contain common pigments? How can you tell if similar-colored pigments from different pens are actually the same compound? Do any similar-colored pigments appear to be different compounds?

4. Why were only water-soluble markers or pens used in this activity?

5. When the inks separate, is this a chemical change or a physical change?

Changing Colors

Introduction

Seeing the world in a wide array of colors is something that can be easily taken for granted. However, the ability to see colors depends on the presence of color receptors in the eye, and the interaction between light and matter.

What is color? Color is the perception of light reflected or emitted by objects. The perception of color can provide some information about the physical and chemical properties of objects seen—for example, in chemistry, color can be used to investigate the composition of substances and materials!

In the arts, colors are used to express and to generate emotions. Indeed, color is an essential component of the visual arts, from painting to photography and film.

When light from the sun, or some type of artificial white light source (e.g., incandescent lamps, LEDs) shines onto an object, we can perceive its color, or colors. White light consists of a mixture of light of all colors, from red to violet. When white light illuminates an object, some of the light is absorbed by the object; some light might pass through it (transmission) if the object is transparent or translucid; and some of the light gets reflected off the object's surface. The color of the object corresponds to the eye's perception of the light that is reflected by the object.

To appreciate why artists and scientists alike have devoted time and effort to the study of color, take film or photography as examples. It is very important for artists in these fields to be able to choose and modify the colors of their work, and the development of color filters by scientists and engineers has made it possible to achieve this very purpose. Color filters, just like the name implies, allow for filtering out certain colors while allowing others to pass through and be seen. Color filters can be placed between object and camera to attenuate or completely remove a color, or range of colors, from images.

Figure 1. Color filters are used in stage lightning to produce light of different colors.

In this investigation, you will explore how color filters work and how they change your own perception of color!

Concepts

- Color
- Color Filter
- Light Absorption
- Light Reflection
- Visible Light

Background

A color filter is a type of optical filter that is widely used in photography and filmmaking. Physical color filters typically consist of a glass or plastic panel that allows light of certain color(s) (or wavelength) to pass through while blocking the rest of the incident light. Digital color filters are applied to images in post-production using software installed on a computer, digital camera, or smartphone. This activity will only deal with certain physical color filters.

In photography, for example, color filters are used to manipulate the colors of light reaching the camera. Filters are placed in the path between the camera and the objects or scene being photographed to block light of a certain color, or color range. Thus, the filter effectively removes the unwanted color(s) from the image captured by the camera.

Color filters commonly work by absorbing the unwanted colors while allowing the rest to pass through. Other types of filters use different methods to achieve the same goal. For instance, there are filters that reflect a color or a range of colors back toward the object instead of absorbing it.

In this investigation, you will explore how color filters work and how to use them to alter your own perception of color!

Experiment Overview

In this investigation, you will explore how color filters selectively remove or block light to change the perceived color of objects.

Materials

- Color filters (red, green, blue, cyan, yellow, and magenta)
- Black paper
- Glue (optional)
- Hole puncher (optional)
- Markers, or crayons, various colors (optional)
- Paper, various colors
- White paper sheet (optional)
- Scissors

Pre-Lab Questions

1. Color filters and other types of filters that change the appearance of photographs are commonly available in most smartphones. What does a color filter do to pictures captured with a smartphone? Provide a few examples.

2. Describe two types of filters that you know about—other than color filters—and briefly explain what they're used for and how they work.

3. An object absorbs visible light of all colors except violet. What is the color of the object? Explain.

Safety Precautions

Please follow all laboratory safety guidelines. Wear safety glasses when handling sharp objects. Tie back long hair. Do not eat or drink anything in the lab. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Part A. Introductory Activity

Follow these steps to explore how color filters work!

1. Cut small pieces of red, green, and blue paper. The pieces of paper should all have the same shape and be about the same size (between 0.5 cm to 1 cm on all sides). **Note:** If you have a hole puncher, you may want to use it to cut out the pieces of colored paper.
2. Place the pieces of red, green, and blue paper on the black paper sheet. You may group the pieces of paper by color and arrange the groups side by side.

3. Grab a red filter and hold it by the edges. **Note:** You may use a piece of cloth or paper towel to gently wipe off any dust or fingerprints from the surface of the filters; do this with the filters lying flat on a bench or desktop.
4. Look at the colored pieces of paper on the black sheet through the red filter. Record your observations in **Table 1**.
5. Repeat steps 3–4 using the green, blue, cyan, yellow, and magenta filters, one at a time. Record your observations for each color filter in **Table 1**.

Table 1. Introductory Activity Results and Observations

Color Filter	Observations
Red	
Green	
Blue	
Yellow	
Cyan	
Magenta	

Part B. Experimental Challenge

Congratulations! You have now used several color filters to observe what happens to red, green, and blue colored objects when seen through any of these filters.

Now your challenge is to select and combine color filters to achieve specific color outcomes!

6. **Challenge I:** Check **Table 2** to see the specific color outcomes that you need to render using any of the color filters provided. Then, record the filter you used to achieve each color outcome, and record any observations in the appropriate cells of **Table 2**.
7. **Challenge II:** Check **Table 3** to see the specific color outcomes that you need to render using any of the color filters provided. Now your challenge is to use a combination of two color filters to achieve the desired color outcome.

Table 2. Experimental Challenge Results and Observations—Challenge I

Color Outcome	Filter(s) Used	Observations
Only red is seen.		
Only green is seen.		
Only blue is seen.		
Red and blue are visible, green is not.		
Green and blue are visible, red is not.		
Red and green are visible, blue is not.		

Table 3. Experimental Challenge Results and Observations—Challenge II

Color Outcome	Filter(s) Used	Observations
Only red is seen.		
Only green is seen.		
Only blue is seen.		

Post Lab Questions

1. Complete **Table 4** to summarize which colors are filtered by each one of the filters used in this investigation.

Table 4. Color Filters Summary

Color Filter	Color(s) Blocked
Red	
Green	
Blue	
Cyan	
Yellow	
Magenta	

2. In the Introductory Activity, which color(s) was blocked by the red filter? How does a red filter block other color(s) and allow only red to pass through? Explain.

3. In the Experimental Challenge, which color was blocked by the cyan filter? How does a cyan filter block this color and allow others to pass through? Explain.

4. A photographer is working on a scene that has red, green, and blue objects in a black background. If the photographer wants to shoot photos of this scene that don't show the red and green objects, which filters would be required? How should the filters be set up between the scene and the camera? Answer this question based on your results from the Experimental Challenge.

5. The color filters used in this investigation work similarly in that they block certain colors and allow other colors to pass through. However, how are the red, green, and blue filters different from the cyan, yellow, and magenta filters?

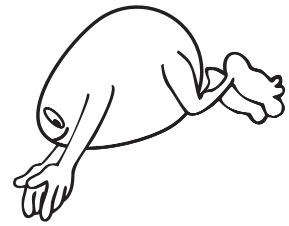
Diving Eggs

A Demonstration of Inertia

Introduction

Students experience the effects of inertia every day—riding in a car, playing sports, even when picking up their backpacks. Present a more dramatic demonstration of Newton's first law by safely dropping three raw eggs into glasses of water, without touching the eggs! Applause is guaranteed!

Concepts



- Balanced forces
- Inertia
- Newton's first law of motion

Materials

Eggs, raw, 3
Water, tap
Broom
Cardboard tubes, 3 (empty toilet paper tubes)
Demonstration tray or jelly roll pan
Drinking glasses, 3
Pie pan or pizza pan, sturdy aluminum
Table
Towel

Safety Precautions

Take care when handling raw eggs. Wash hands thoroughly with soap and water after handling eggs. Clean up spills immediately. Wear safety glasses. Observers should be a safe distance away from the trajectory of the pie pan. Follow all laboratory safety guidelines.

Procedure

1. Obtain three identical tall drinking glasses, large enough for an egg to fit in sideways.
2. Fill each glass about three-fourths full with tap water.
3. Place a demonstration tray or jelly roll pan 1 cm from the edge of a table. *Note:* The bottom of the tray must be completely flat.
4. Place two of the glasses in the tray next to the edge. The rim of the glasses should be near, but not extending over, the edge of the table.
5. Place the third glass between the other two, forming a triangle shape. See Figure 1.
6. Obtain a sturdy aluminum pie plate or a small aluminum round pizza pan.
7. Center the aluminum pan on top of the three glasses. The edge of the pan should extend slightly beyond the edge of the table.
8. Obtain three empty cardboard toilet paper tubes.
9. Stand the tubes vertically on the aluminum pan, centering one tube over each glass (see Figure 2).
10. Obtain three raw eggs. *Note:* For practice, hard boiled eggs may be used. Once the demonstration has been perfected, use raw eggs.
11. Balance one egg on top of each cardboard tube, laying the egg lengthwise across the top of the tube. Do not fit the narrow end of the egg into the tube; the egg should just rest on top (see Figure 2).
12. Obtain a broom and place the bristles on the floor by the table with the handle extending upward.
13. Holding on to the broom handle, and facing the egg setup on top of the table, step on the bristles of the broom with one foot.

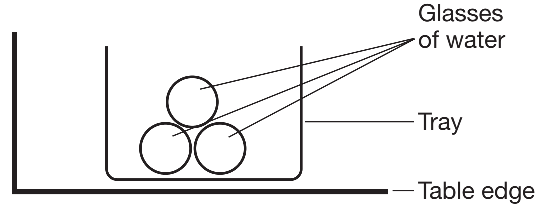


Figure 1. Overhead view

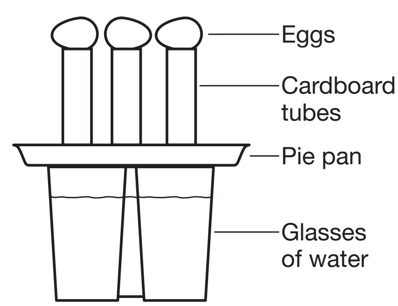


Figure 2.

14. Pull back on the broom handle like a lever. See Figure 3.
15. *Without letting go of the broom handle*, carefully test to see if the handle will hit the aluminum pan *between* the two closer glasses when the handle is released. If not, adjust the position of the broom accordingly. The handle should not hit any of the glasses or the tray.
16. Continuing to step on the bristles, pull the broom handle back.
17. Let go of the broom handle and watch as the eggs "dive" safely into the glasses of water.

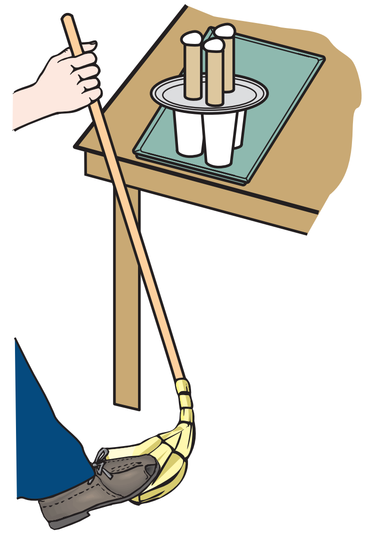


Figure 3.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. Eggs may be disposed of in the trash according to Flinn Suggested Disposal Method #26a. Egg whites and yolks from broken eggs may be disposed of down the drain with plenty of water according to Flinn Suggested Disposal Method #26b. If necessary, sterilize the glasses and demonstration tray with a 10% bleach solution, then rinse with water.

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

Disciplinary Core Ideas: High School
- HS-PS2 Motion and Stability: Forces and Interactions
  - PS2.A: Forces and Motion
  - PS2.B: Types of Interactions

Science and Engineering Practices
- Developing and using models
- Planning and carrying out investigations

Crosscutting Concepts
- Patterns
- Cause and effect

Tips

- Practice with other objects before using raw eggs. Hard boiled eggs, rubber balls, or any other objects similar in size and mass may be used.
- Thin aluminum pie pans may dent with the force of the broom handle, resulting in a less elastic collision. These pans are not recommended for this demonstration.
- Diving Eggs is available from Flinn Scientific as a Super Value Kit, "Diving Eggs Inertia Challenge" (Catalog No. AP7419). The kit includes weighted plastic eggs for practice.
- Using clear drinking glasses allows students to see the eggs after they have dropped into the water. Large beakers may be used instead of drinking glasses.
- Videotape the demonstration, and then play it back in slow motion.

Discussion

Newton's first law of motion states that an object at rest tends to stay at rest unless a net force acts on it. This law is also known at the law of inertia. *Inertia* is the tendency of an object to resist change in motion. Inertia is directly related to mass—the greater the mass of an object, the greater its inertia. In the "Diving Eggs" setup, all the forces are balanced with all objects at rest. A net horizontal force is supplied by the moving broom handle. This force acts upon the aluminum pan, which then accelerates in the direction of the applied force. When the edge of the pan hits the cardboard tubes, the tubes accelerate in the direction of the force also. The eggs do not move with the tubes because of their greater inertia. Since no horizontal force acts on the eggs, however, once the force holding them up is gone, the only remaining force is gravity, and the eggs drop into the glasses of water.

Materials for *Diving Eggs* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7419	Diving Eggs Inertia Challenge—Super Value Kit
GP1025	Beaker, 400-mL

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

Discover Newton's Second Law

Introduction

Newton's second law of motion states that an object or system's acceleration is equal to the net force applied to the object or system divided by the object or system's mass.

$$\vec{a} = \frac{\Sigma \vec{F}}{m} \qquad \textit{Equation 1}$$

Thus, if the same force were applied to two objects of different mass, the less massive object would experience a greater acceleration. In this lab you will discover this relationship first-hand!

Concepts

• Experimental Design	• Force and Acceleration
• Variables - control, dependent, independent	• Direct and Inverse Relationships
• F = ma	• Graphing Data

Background

Force and Acceleration

Multiple forces acting in complex systems may be added together to find the resulting acceleration. Acceleration along a given axis can only be the result of all the forces in that axis. Forces in the y direction will not affect acceleration in the x-direction, and vice versa. For example, consider a game of tug-of-war between two teams pulling on a rope with great force. The system will often experience very little acceleration because the two forces are acting in opposition along the same axis.

Free body diagrams are often used to describe the forces that act on objects. For example, the Atwood's machine in Figure 1 consists of two masses connected with a string suspended on a two-pulley system. The machine was developed in the late 18th century to indirectly measure acceleration due to gravity. If the masses are equal, the net force acting on both masses in the y direction is 0 N and the system is static. However, if one of the masses is heavier than the other, the lighter mass will accelerate up and the heavier mass down owing to a net nonzero force in the y direction. In this lab, a modified Atwood's machine, shown in Figure 2, will be used to quantitatively explore the mathematical relationships associated with Newton's second law. The acceleration of a hanging weight system will be determined by recording the time it takes the weight to travel a measured distance.

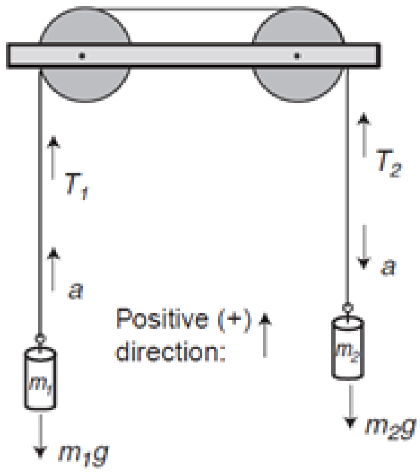


Figure 1.

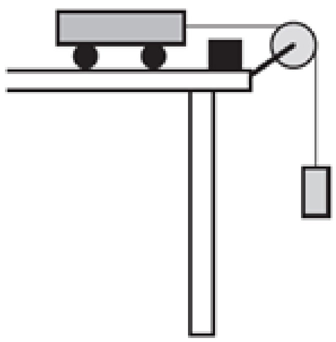


Figure 2.

The acceleration can be calculated by assuming free-fall conditions and assigning an initial velocity of 0 m/s to the system. As a result, the traditional equation (Equation 2), which describes the distance an object in free fall travels, reduces to Equation 3. You will use Equation 3 for the calculations needed in this lab.

Equation 2

$d = \frac{1}{2}at^2 + v_i t$

where
d is the distance the object moves (in m)
a is the acceleration of the object (in m/s^2)
t is the time (in seconds)
v_i is the initial velocity of the object

Equation 3

$a = 2d/t^2$

Experiment Overview

This activity's purpose is to gather data to discover what Newton first did, that the mass and acceleration of an object are related by the equation F = ma.

Pre-Lab Questions

1. If a cart travels 0.6 m in 2.4 s, what is its acceleration?

2. According to the equation a = bc, what type of algebraic relationship (direct or inverse) exists between the quantities a and c? Draw a simple graph to describe the relationship between a and c. Assume b is a constant.

Materials

• Balance, 0.1 g precision	• Plastic bag
• Hall's carriage	• String, 130 cm
• Meter stick	• Table pulley
• Timer	• Washers

Safety Precautions

While the activity is considered nonhazardous, protective eyewear is recommended because projectiles may be inadvertently launched during the activity. Please follow all normal laboratory safety guidelines.

Procedure

Introductory Activity

1. Measure and mark distances of 0.1 m and 1.1 m from the edge of a tabletop with a meter stick or ruler and masking tape. The cart will traverse this distance. The distance may be varied to accommodate the height of available tables. Low tables will require shorter distances.

2. Secure a table pulley to the table's edge.

3. Attach a plastic bag to one end of a string, approximately 130-cm long, using a looping knot. See Figure 3. Attach the other end of the string to the cart.

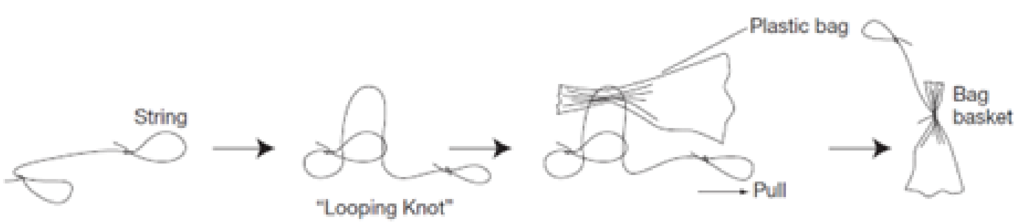


Figure 3.

4. Weigh one washer and place it inside of the plastic bag.

5. Add four washers to the cart and weigh.

6. Place the cart at the 1.1 m tape mark, farthest from the table pulley. Hold the cart in place and lay the string over the top of the pulley.

7. Release the cart and use a timer to time its travel between the tape marks.

8. Perform steps 6–7 ten times and display the collected mass and time data in Data Table 1.

9. Use Equation 3 to calculate the acceleration for each trial; and the average acceleration. Display the values in Data Table 1.

Data Table 1

Trial	Time (s)	Acceleration (m/s^2)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average		

Experimental Challenge: Relationship Between Mass and Acceleration

By completing the introductory activity, you have learned how to use the materials provided to calculate the acceleration of a system. Your challenge is to use what you have learned to develop a simple procedure for determining the relationship between the mass and acceleration of the system.

To complete this Experimental Challenge, follow these steps:

1. Form a working group with other students and discuss the following questions.

   a. Using Newton's second law, F = ma, what variable should be held constant to determine the relationship between mass and acceleration?

b. How could the variable identified in the previous question be held constant?

c. What variable could be changed to study the relationship between acceleration and mass?

d. How can that variable be altered?

2. Write a step-by-step procedure to determine the relationship between the mass and acceleration of the cart-mass system. Identify the independent and dependent variables, and any variables that should remain constant.

Post Lab Questions

1. Construct a graph of mass versus acceleration using the data you collected in the Experimental Challenge part of the experiment.

2. What type of relationship do the data indicate exists between mass and acceleration?

3. Consider the equation F = ma. Explain why the value of a must decrease as m increases if F is held constant.

Hovercraft Forces

Introduction

When we look around us, all objects have forces acting on them. The way those forces act on those objects can tell us about how the objects move. For example, if you apply enough force to a table, you can get it to move. If you drop your pencil, the force of gravity will pull your pencil down to earth, speeding up until it hits the floor. In this lab, you will make a hovercraft and then explore how understanding the forces acting on the hovercraft affects how it moves.

Concepts

- Newton's 1st Law of Motion
- Friction
- Forces
- Balanced forces
- Unbalanced Forces
- Gravity

Background

Newton's first law of motion tells us that an object at rest stays and rest and an object in motion stays in motion at a constant speed and direction unless acted upon by an unbalanced force. This means that if all the forces acting on an object balance each other out, the object will either not move if it's already not moving or move at the same speed and in the same direction if it was already moving.

Balanced forces means that the forces acting on the object going up must equal the forces on the object pulling it down. Or if there are forces on the object pushing it to the right, the same amount of force must be pushing that object back to the left.

A simple example of this would be a book sitting on the table. The force of **gravity** is pulling the book down. We know this because if the table disappeared, the book would fall. The table is pushing up on the book, preventing it from falling. Because the book is not moving, we know that the force of gravity and the force of the table on the book must equal each other and be in opposite directions to each other.

This is also true of objects that are moving at a constant speed. This can be tricky to understand because of friction. **Friction** slows down objects that move across surfaces, but sometimes we pretend friction doesn't exist. For example, if you think of a figure skater gliding across ice. If we pretend friction doesn't exist, there would be no force acting on the figure skater in the horizontal direction. This means that if she was already moving, without friction, she would move at the same speed in the same direction forever (or until another force acts on her – like running into a wall).

In order to get an object that is at rest moving or to change speed or direction of a moving object there must be an **unbalanced force** acting on that object. Forces that are unbalanced means that the force going in one direction is bigger than the force going in the opposite direction. For example, if I push a person standing on a skateboard who is initially at rest, I can get them to move if I apply a force greater than the force of friction holding that person in place.

If an apple falls from a tree, the force of gravity is the only force acting on the apple, pulling it down to the earth. There is no opposing force acting up on the apple, so it speeds up as it falls to the ground.

If the forces on an object are unbalanced, the object will be changing speed. This can be speeding up or slowing down.

Experiment Overview

In this activity, you will make a mini hovercraft and determine if the forces acting on it are balanced or unbalanced. You will then observe the motion of the hovercraft and connect that to the forces acting on the hovercraft.

Materials

- Pushpin
- Cardboard circle
- Balloon
- Small paperclip
- Bottle cap
- Tape or hot glue
- Scissors
- (optional) Markers, colored pencils, stickers

Pre-Lab Questions

1. Define the following terms.

- Speed:
- Force:
- Friction:
- Gravity:

Safety Precautions

Take care when using the pushpin. Ensure fingers are not in the way of the push pin before creating holes in the bottle cap. Be careful when using scissors.

If using a hot glue gun, be sure not to touch the hot part of the tool with your hands. Also be sure to place the glue gun in a safe location after use away from any materials.

Procedure

Part A – Introductory Activity

1. Poke several holes in the top of your bottle cap using a pushpin. You may select the number of holes you want, but the total number should be around 5-10.
2. Using scissors, cut a circle out of the cardboard. In the center of the circle, cut a small hole. The hole must be smaller than the size of the plastic bottle cap.
3. Using either tape or hot glue, attach the bottle cap to the cardboard circle. The flat side of the cap should be facing up and the open end of the cap should be in contact with the cardboard. Be sure that there are no gaps in the connection between the bottle cap and the cardboard so that no air will leak.
   Figure 3. (bottle cap on cardboard.png)
4. Blow up the balloon and twist it shut. Do not tie it. You may use a small paperclip to hold the balloon closed.
5. Carefully attach the balloon to the top of the bottle cap by stretching open the end of the balloon and pulling it over the bottle cap. You may tape it into place if necessary.
   Figure 4. (hovercraft.png)
6. Remove the paperclip if it was used or untwist the balloon, allowing the air to exit the balloon. Give it a small push and observe its motion.
7. Describe the motion of your hovercraft.

8. You may remove the balloon and re-inflate it to perform the second part of this lab.

Part B -Experimental Challenge

1. Create a scenario with your hovercraft where the forces acting on it are balanced. You may choose to ignore friction.
2. Describe the motion of your hovercraft.

3. Draw a representation of all the forces acting on your hovercraft.

4. Create a scenario with your hovercraft where the forces acting on it are unbalanced.
5. Describe the motion of your hovercraft.

6. Draw a representation of all the forces acting on your hovercraft.

Post Lab Questions

1. What must be true about all of the forces acting on a hovercraft if it is not moving?

2. What must be true about all of the forces acting on a hovercraft if it is moving at a constant speed?

3. What must be true about all of the forces acting on a hovercraft if it is speeding up across the table?

4. If a book is pushed across a table with a force of 10 N and friction is holding it back with a force of 6 N. Describe how the object will move. Explain how you know using numbers.

Electrical Conductors and Insulators

Introduction

Why is the inside of wires used for electrical circuits made of thin metal threads? And why are the thin metal threads in these wires coated with plastic?

You may be familiar with the concept of electricity and how certain materials and objects allow electricity, or an electric current, to pass through them. Metals are known for their ability to conduct or allow electricity to travel through them. This is why wires used in electrical appliances and circuits in general are made with some type of metal.

Electrical conductivity is a physical property of matter that describes the ability of a material to allow electricity to pass through them. Materials that conduct electricity are called *conductors*; most metals are good conductors and even carbon, a non-metal, conducts electricity.

On the other hand, materials that do not conduct electricity are called *insulators*. Plastics, sand, and wood are examples of insulators.

In the laboratory, an instrument known as a conductivity meter is used to determine the electric conductivity of various types of materials including solids, liquids and solutions. In this investigation, you will build your own conductivity meter to test the conductivity of household solids and liquids.

Concepts

- Conductivity
- Conductor
- Electricity
- Electron
- Insulator
- Physical Properties

Background

Electricity is a type of energy—just like heat, sound, chemical, and nuclear energy. Electricity can flow or move in the form of electric currents, or it can be static and confined to an object or place. Static electricity or simply "static" is what you may experience as an electric shock when touching a doorknob during a dry, cold winter day.

Electricity is related to the presence of charges (negative or positive) in matter. To get a better grasp of what this means, one must think about the properties of matter at the level of atoms.

Atoms make up every material and living organism you can think of, yet they are tiny and invisible to the naked eye. Each atom has a nucleus made up of nuclear particles called protons and neutrons. Each proton has a positive charge (+) while neutrons—like the name neutron implies—are neutral and have no charge. Surrounding the atom nucleus are the electrons, which are much smaller than protons and neutrons. Each electron carries a negative charge (–).

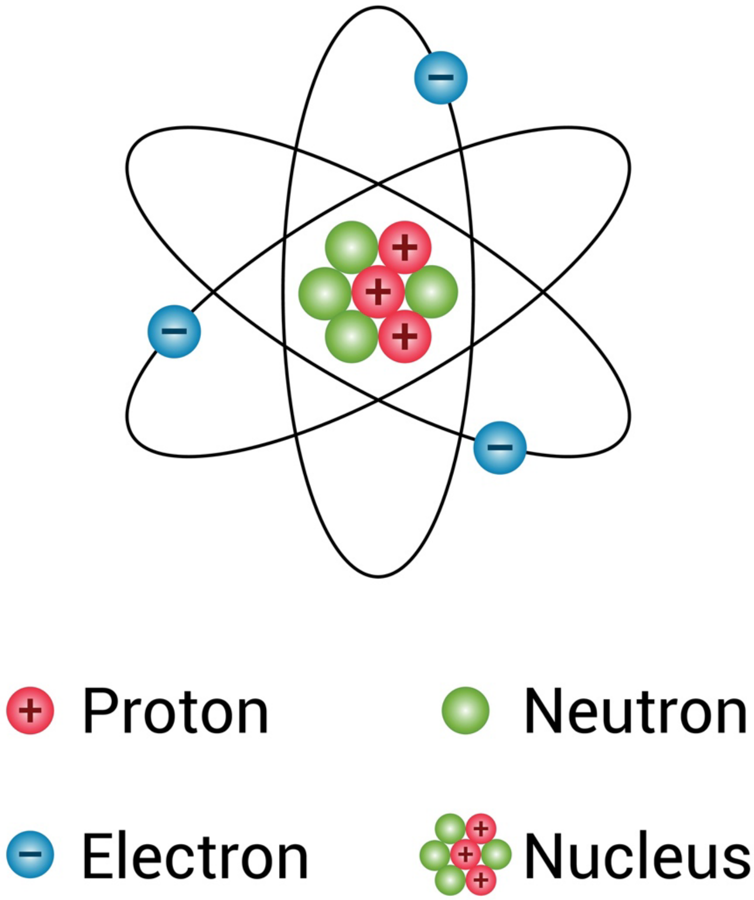


Figure 1. Model of an atom showing protons and neutrons in the nucleus (i.e., the core or center of the atom) and electrons surrounding the nucleus.

Atoms tend to have an equal number of protons and electrons, such that the number of positive (protons) and negative charges (electrons) are equal, and the atom stays neutral. However, some atoms may gain or lose electrons, and become negatively charged (gaining electrons) or positively charged (loosing electrons). When atoms become charged (positively or negatively), electrons tend to move or “jump” between atoms.

The continuous movement of electrons between atoms in a material is called an electric current. Metals like copper and gold are examples of materials in which electrons can easily move through forming electric currents. These types of materials are called *conductors*.

On the other hand, glass, wood, and pure water are examples of materials that do not conduct electricity. These materials are called *insulators* because electric currents can’t flow or pass through them.

In this investigation, you will build a conductivity tester to test various household substances and materials for their ability to conduct electricity.

Experiment Overview

In this investigation, you will build a small device that can be used to test the electrical conductivity of various household substances and materials.

Materials

- Button battery, 3.0 V
- Copper tape
- Fine tip marker, or pen
- LED light
- Paper clips, 3
- Paper cups, or small beakers, 2
- Ruler
- Scissors
- Small sample objects for testing, 5
- Table salt (sodium chloride)
- Tape
- Teaspoon, or scoop (optional)
- Water, distilled
- Wooden stick

Pre-Lab Questions

1. Lightning rods are used to protect buildings from structural damage that lightning may cause. A lightning strike or lightning bolt is a powerful discharge of electricity from the atmosphere to the ground. Lightning rods receive the electricity discharge from the atmosphere and direct it to the ground so that it doesn't pass through the building's structure.

Figure 2. Image of a lightning rod set on a roof.

If lightning rods are to protect buildings from lightning strikes, should lightning rods be made of materials that are conductors or insulators? Explain.

2. Why do electrical appliances such as straightening irons and hair dryers come with warning tags not to use them while in the shower or bathtub?

Safety Precautions

Please follow all laboratory safety guidelines. Wear safety glasses. Tie back long hair. Do not eat or drink anything in the lab. Use caution when handling scissors and other sharp objects such as metal wire and tape. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

Part A. Introductory Activity

Follow these steps to build your conductivity tester:

1. To start, notice that the LED light has two prongs, one longer than the other. The longer prong is called the "anode" and it is represented or marked with a plus sign (+). The shorter prong is called the "cathode" and it is represented or marked with a negative sign (–).
2. Examine the battery and note that it has a positive and a negative side. The positive side is typically engraved with a plus sign (+), which leaves the opposite side as the negative one (–).
3. Place the battery between the LED prongs such that the positive (longer) prong on the LED is in contact with the positive side of the battery. The negative prong on the LED should contact the negative side of the battery. The LED should immediately light up. **Note:** If the LED doesn't light up, make sure the battery is correctly positioned between the LED prongs. If the light is not coming up still, invert the position of the battery between the LED prongs (see **Figure 3**).

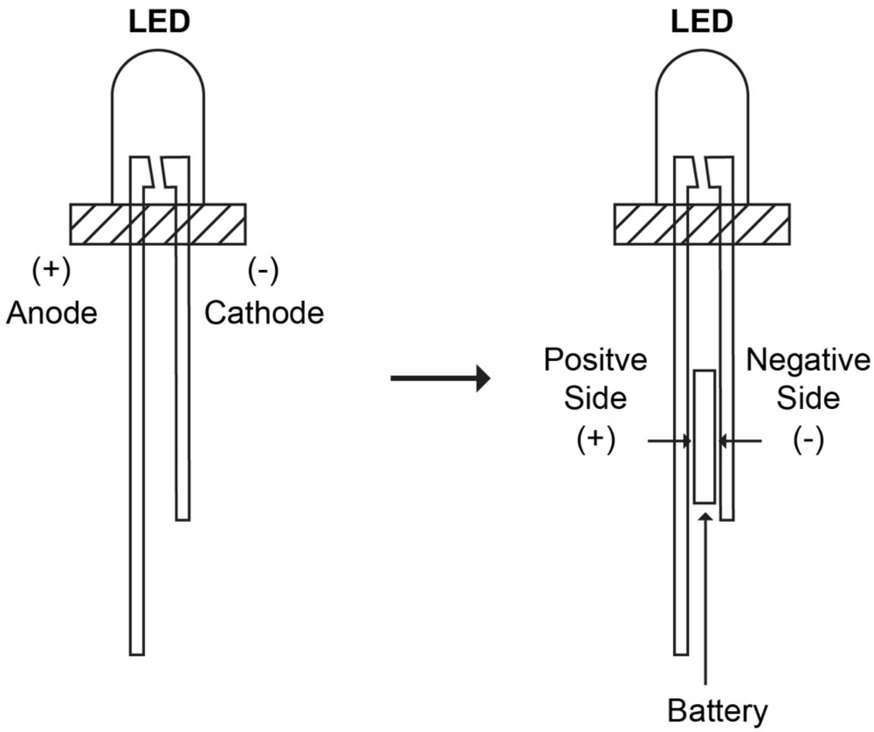


Figure 3. Testing the LED light with a battery.

4. Use scissors to cut two strips of copper tape. Each strip should have a length of approximately 14 cm.
5. Mount the LED on the end of the wooden stick so one prong extends downward on each side of the stick (see **Figure 4**). Use a marker to write a plus sign (+) on the side of the stick with the positive LED prong.

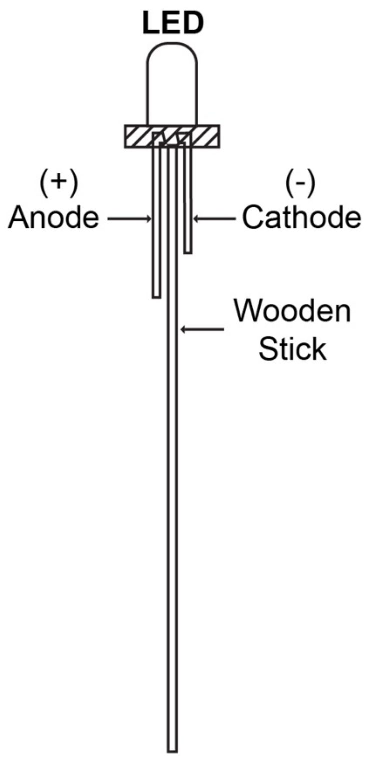


Figure 4. Mounting the LED on the wooden stick.

6. Gently peel the backing from one strip of copper tape and stick it to one side of the wooden stick, covering first the LED prong and then moving down the stick. Be sure to completely cover the prong of the LED so there is a permanent connection between the prong and the tape (see **Figure 5**).

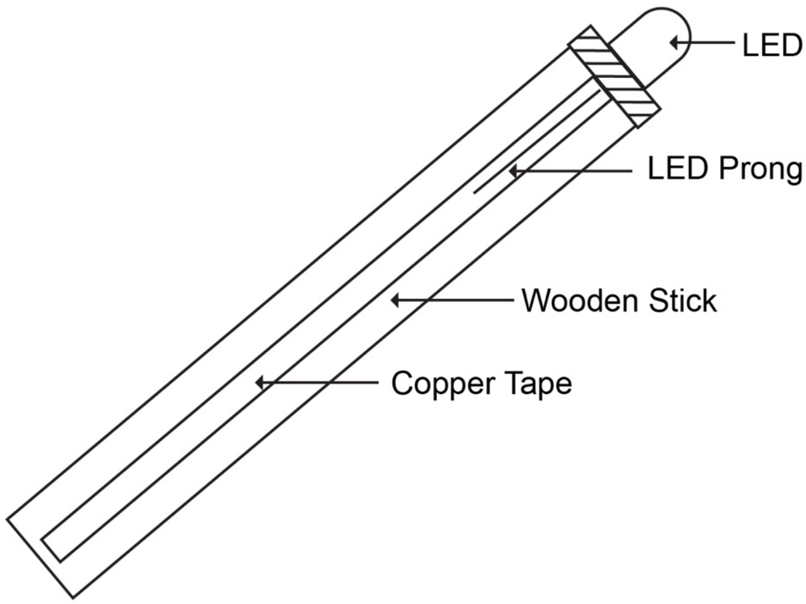


Figure 5. Using copper tape to attach the LED to the wooden stick.

7. Repeat step 7 with the other side of the wooden stick. Make sure to completely cover the LED prong with the copper tape strip on this side.
8. Place the battery with its negative pole on the side of the wooden stick that has the negative LED prong. The battery should be placed 1.0-1.5 cm from the bottom of the wooden stick. (see **Figure 6**).

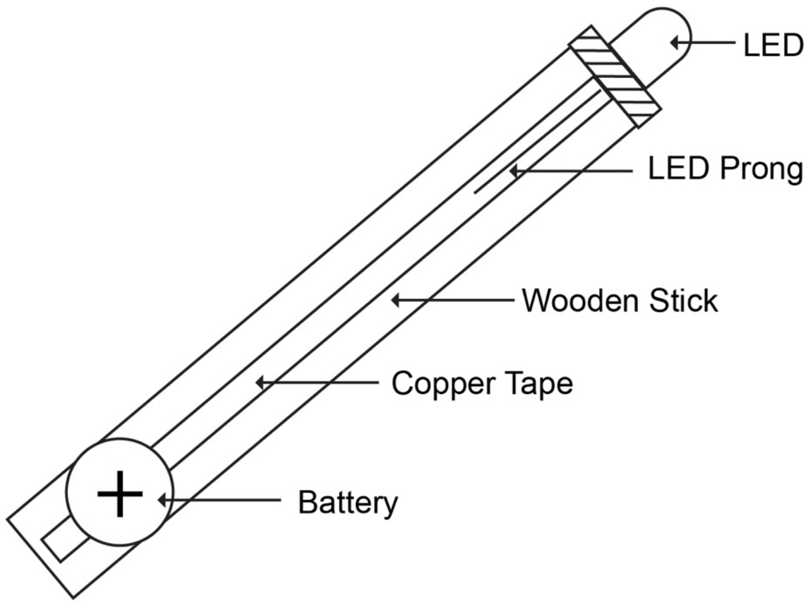


Figure 6. Adding the battery to the device.

9. Place a paper clip against the positive side of the battery, and another one on the opposite side of the wooden stick. About half the length of each paper clip should stick out from the bottom tip of the wooden stick.
10. Wrap a piece of tape around the paper clips and battery to hold them tight in place. At this point the device should look like the sketch show in **Figure 7**.

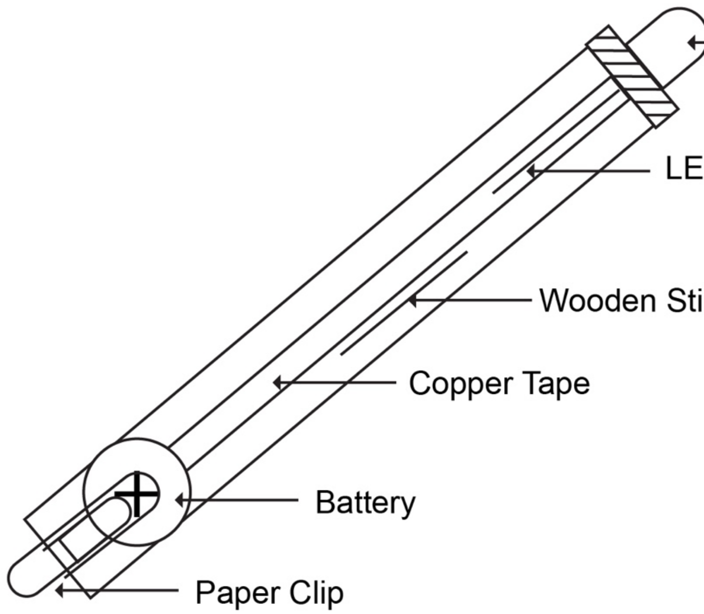


Figure 7. Diagram of the conductivity tester device.

11. To test your conductivity tester, touch the tips of the paper clips on the device with another paper clip. The LED should light up. The paper clip used to contact the two clips attached to the device closes the electric circuit loop of the device. When the loop is closed, electricity can flow from one side of the battery, through the LED and back into the opposite side of the battery.

Part B. Experimental Challenge

Congratulations! You have built your own conductivity tester device!

Now your challenge is to test the conductivity of different samples described in **Table 1**. Conductors will cause the LED on the conductivity tester to light up, while insulators will not cause the LED to emit light.

12. To test the electrical conductivity of each sample, touch the surface of the sample with the paper clip leads of the conductivity tester. Test all the dry samples first.

13. Now test the distilled water. Only the tips of the paper clips on the conductivity tester must be immersed into the liquid.

14. Dissolve one teaspoon of table salt (sodium chloride) in one cup of distilled water and test the conductivity of this solution.

Table 1. Electrical conductivity of various household substances and materials.

Sample	Conductor or Insulator?	Observations
Distilled Water		
Distilled Water + Table Salt		

Post Lab Questions

1. Reflect on the results and observations from the Introductory Activity. What happened when a third paper clip is used to contact both paper clips attached to the device? What is the role of this third paper clip?

2. Think about the objects and substances that you determined to be conductors or insulators in the Experimental Challenge.

   a. Why does the LED light up when both paper clips touch a conductor?

b. Why doesn't the LED light up when both paper clips touch an insulator?