PHYSICAL SCIENCE EXPLORED

LAB & ACTIVITY GUIDE

Luke & Trisha Gilkerson
with Bekah Kohlmeier

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Physical Science Explored: Student Lab Guide

Journey Homeschool Academy

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GET READY TO... EXPLORE PHYSICAL SCIENCE

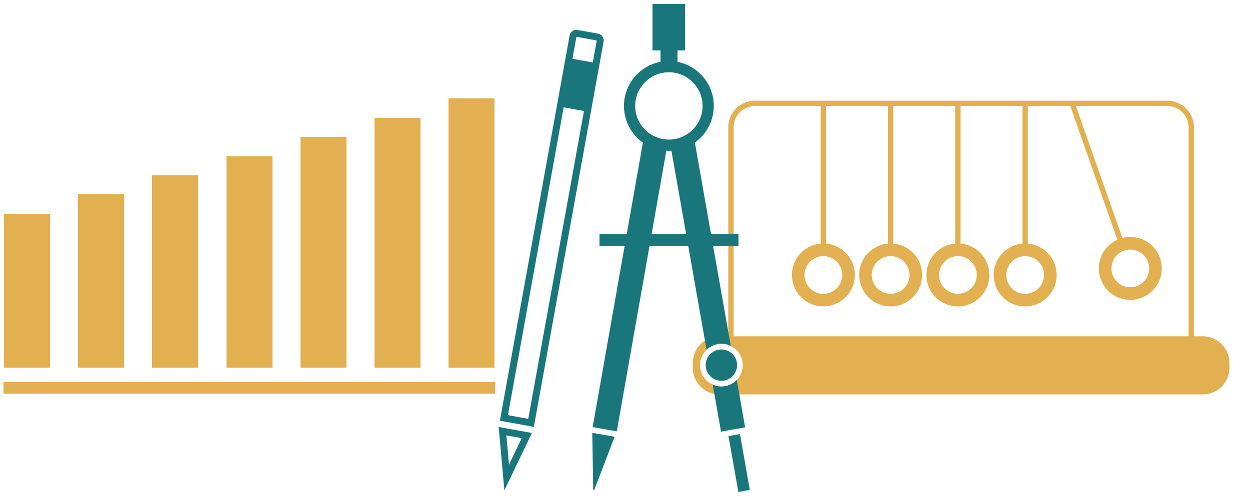
While not everyone is a science enthusiast, many people are able to recall the excitement of hands-on learning in the lab—those unforgettable moments of discovery! This guide is here to help you embrace that excitement.

This lab guide, designed specifically for Levels B and C of the Physical Science Explored course, offers detailed written instructions for each lab, along with the space needed for sketches and answers to your lab questions.

Throughout this school year, you'll embark on an exploration of the laws that govern matter and energy. Get ready to discover how the complexities of the physical world reflect the creativity, order, and power of our Creator!

See you inside the course!

Trisha Gilkerson



LESSON 1

FREEZING LIQUIDS & EXPLORING THE SCIENTIFIC METHOD

Put your scientific skills to the test by freezing and comparing different household liquids! In this lab, you'll use the scientific method to predict and measure which liquid will melt the fastest.

Supplies

- 3 household liquids (water, milk, orange juice, or whatever you have on hand!)
- Ice cube tray
- Timer
- Plate

Instructions

1. Read through the experiment first. As you read, see if you can identify the problem for this experiment and write it below.
2. Pour equal amounts of each liquid into an ice cube tray and freeze. Make two ice cubes for each liquid.
3. Form a hypothesis about which of the three substances will melt the fastest and write it in the space below.
4. Place one of the ice cubes (Substance #1) out on a plate and start the timer. Return the tray with the other cubes to the freezer while you do this.

5. Stop the timer as soon as the ice cube is completely melted. Record the time in the data table below under "Trial #1 Time".
6. Complete steps 4 and 5 with the ice cubes made from Substance #2 and Substance #3.
7. Complete steps 4 and 5 with the second set of cubes and record your data in "Trial #2 Time."

Problem

____

____

Hypothesis

____

____

Data Table

	Type of liquid	Trial #1 time	Trial #2 time
Substance #1			
Substance #2			
Substance #3			

Questions

1. What was the independent variable in this experiment? ______________________

   ____

2. What was the dependent variable? ______________________________

   ____

3. Which of the ice cubes melted the fastest? __________________________

   ____

4. Was your hypothesis correct? Why or why not? ______________________________

____

5. What is one reason why that ice cube may have melted faster than the others?

____

____

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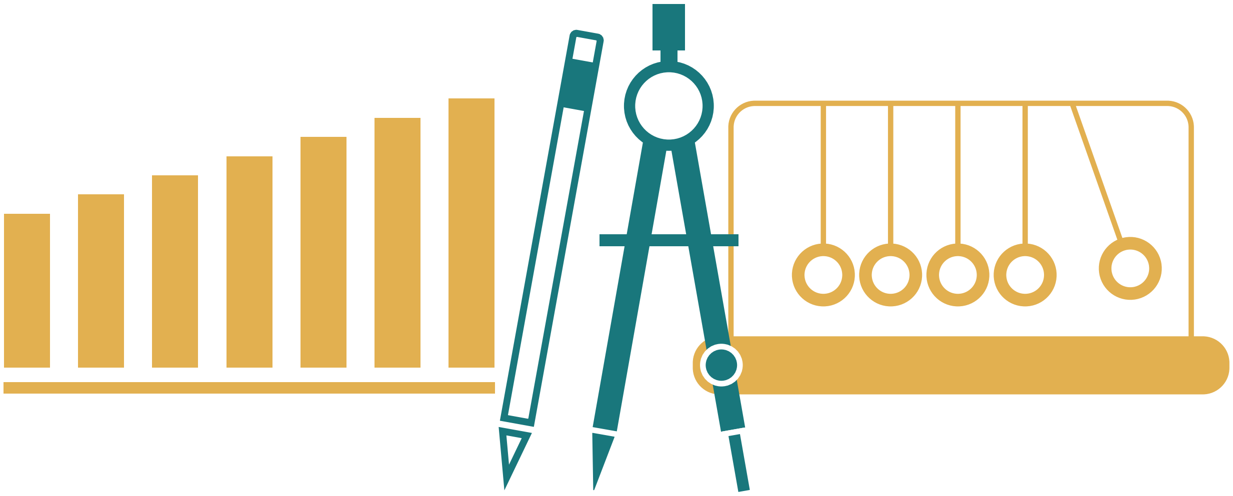

LESSON 2

SCIENTIFIC MEASUREMENTS

Understanding how to take accurate measurements is an important skill in science that you'll continue to use throughout your academic career. In this lab, you'll learn how to take measurements for length, volume, and time, and then complete unit conversions.

Supplies

- Ruler
- Textbook
- Stopwatch
- 25 mL graduated cylinder

Instructions

1. Using your ruler, measure the length of your textbook from the bottom of the cover to the top. Record your answer in centimeters and round to the nearest hundredth (two numbers to the right of the decimal place).
2. Measure the width of your textbook from the left edge of the cover to the right edge. Record your answer in centimeters and round to the nearest hundredth.
3. Measure the height (thickness) of your textbook from the bottom of the back cover to the top of the front cover. Record your answer in centimeters and round to the nearest hundredth.
4. Fill your graduated cylinder about halfway with water.
5. Measure the volume of water in your cylinder by finding the *meniscus*—the bottom of the curve at the top of the water—and recording this number. Record your answer in milliliters and round to the nearest hundredth.

6. Using a stopwatch, measure how long it takes for you to complete 10 jumping jacks. Record your answer in seconds and round to the nearest hundredth.

Data Table

Textbook length	
Textbook width	
Textbook height	
Water volume	
Jumping jacks time	

Questions

1. Convert the length, width, and height of your textbook into meters.
   a. Length ______________________________
   b. Width ______________________________
   c. Height ______________________________
2. Calculate the volume of your textbook in meters cubed by multiplying the length, width, and height from your answers in question #1.

   ____
3. How many liters of water did you have in your graduated cylinder (convert milliliters to liters)?

   ____
4. How many milliseconds did it take for you to do 10 jumping jacks (convert seconds to milliseconds)?

   ____
5. The equipment scientists use to measure is very important for ensuring accurate measurements. You used a ruler to measure your textbook. What are some other tools you could use to measure the length (think about if you were measuring your height, the length of a room, the distance traveled between two cities, etc.)?

   ____

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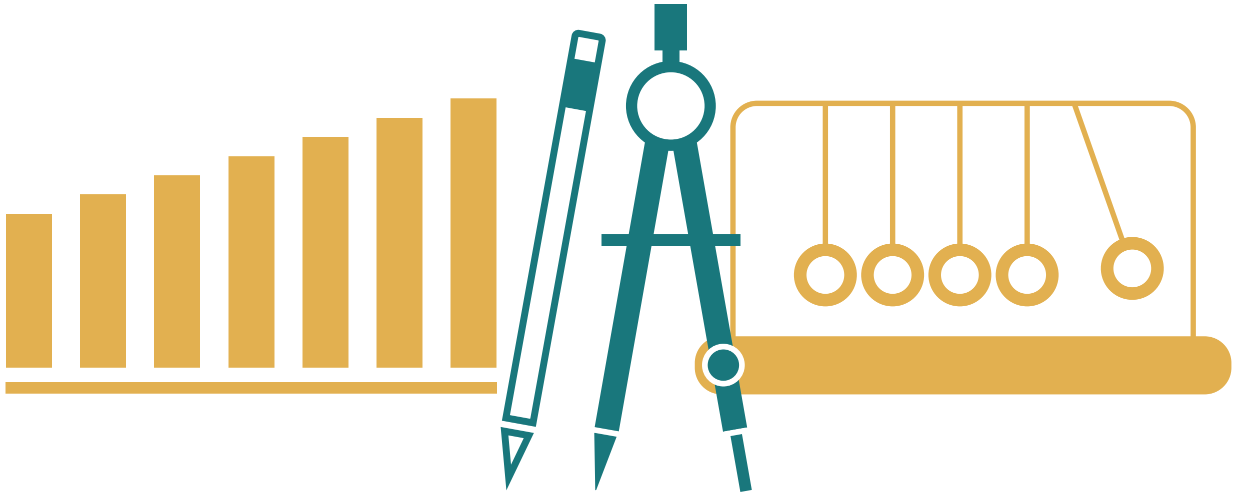


LESSON 3

BULLSEYE! ACTIVITIES TO INVESTIGATE ACCURACY & PRECISION

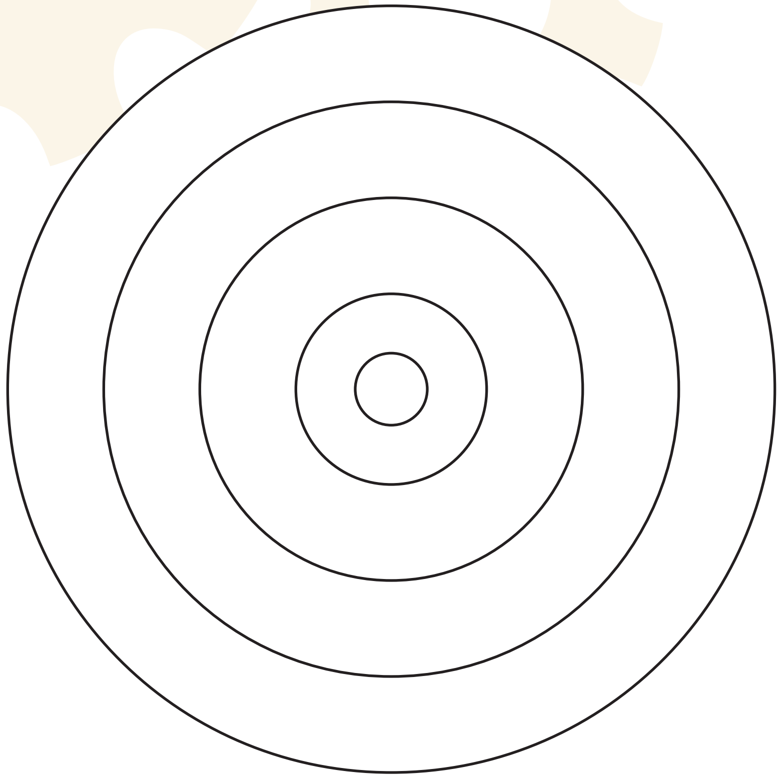
It is important for scientific measurements to be both accurate and precise. In this lab, you will complete several activities to help you understand the difference between these concepts.

Supplies

- 3 pieces of scrap paper
- Trash can
- 3 coins
- Plastic cup (or any object to use as a target)

Activity 1 Instructions

1. Close your eyes and place four X's on the target on the next page.
2. Open your eyes and answer the questions below.



Questions

1. Were your X's accurate? Why or why not? ______________________________

____

2. Were your X's precise? Why or why not? ______________________________

____

Activity 2 Instructions

1. Crumple up three pieces of scrap paper to make three balls.
2. Starting at the trash can, take six large steps away and turn around so you're facing the trash can.
3. Throw each of the three balls, trying to make them into the trash can.
4. Answer the questions below.

Questions

1. Draw a sketch showing where your paper balls landed in relation to the trash can.

2. Were your throws accurate? Why or why not?

3. Were your throws precise? Why or why not?

Activity 3 Instructions

1. Find a large, flat, smooth surface (table, wooden floor, etc.) and place a plastic cup (or other object) at one end of the surface.
2. From the opposite end of the surface, slide each of the three coins to try to hit the cup.

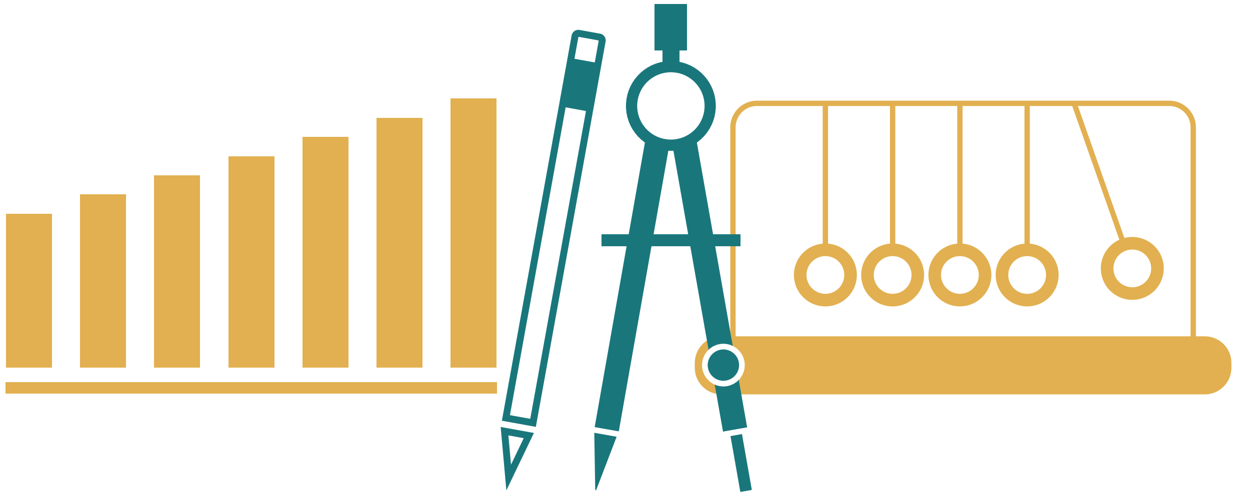
Questions

1. Draw a sketch showing where your coins landed in relation to the cup.

2. Were your shots accurate? Why or why not?

3. Were your shots precise? Why or why not?

4. Why do you think it's important for measurements in science to be accurate and precise?



LESSON 4

CHANGE IN ACTION: IDENTIFYING PHYSICAL & CHEMICAL TRANSFORMATIONS

By experimenting with salt water, ice cubes, and a vinegar-baking soda reaction, you'll observe and differentiate between these types of changes.

Supplies

- Plastic bottle
- 25 or 50 mL graduated cylinder
- Vinegar
- Small pot
- Balloon
- Funnel
- Water
- Stove
- Teaspoon
- Baking soda
- Salt
- Ice cube

Salt Water Instructions

1. Mix one teaspoon of salt with one cup of water in a small pot. Stir until the salt is fully dissolved (when you can no longer see salt in the water).
2. Record your observations in the data table below. Classify the type of changes as physical or chemical and explain your reasoning.
3. Carefully heat the salt water until the water is completely gone.

4. Record your observations in the data table below. Classify the type of changes as physical or chemical and explain your reasoning.

Ice Cube Instructions

5. Place an ice cube on the table or counter for several minutes and record your observations.
6. Record your observations in the data table below. Classify the type of changes as physical or chemical and explain your reasoning.

Vinegar & Baking Soda Instructions

7. Using the graduated cylinder, add about 5 mL of vinegar to the plastic bottle.
8. Using the funnel, put 2 tsp of baking soda into the balloon.
9. Carefully stretch the balloon over the bottle opening, making sure the baking soda stays in the balloon.
10. Lift up the balloon, letting the baking soda fall into the vinegar.
11. Record your observations in the data table below. Classify the changes as physical or chemical and explain your reasoning.

Data Table

	Observations	Type of change and why
Mixing salt & water		
Evaporating water		
Ice cube		
Baking soda & vinegar		

Questions

1. Was it difficult to tell if the changes were physical or chemical? Why or why not?

2. What type of substance (element, compound, homogeneous mixture, or heterogeneous mixture) was the salt water after you stirred it?

3. What type of substance (element, compound, homogeneous mixture, or heterogeneous mixture) was left over after the water evaporated?

4. What type of substance (element, compound, homogeneous mixture, or heterogeneous mixture) was present when the ice cube melted?

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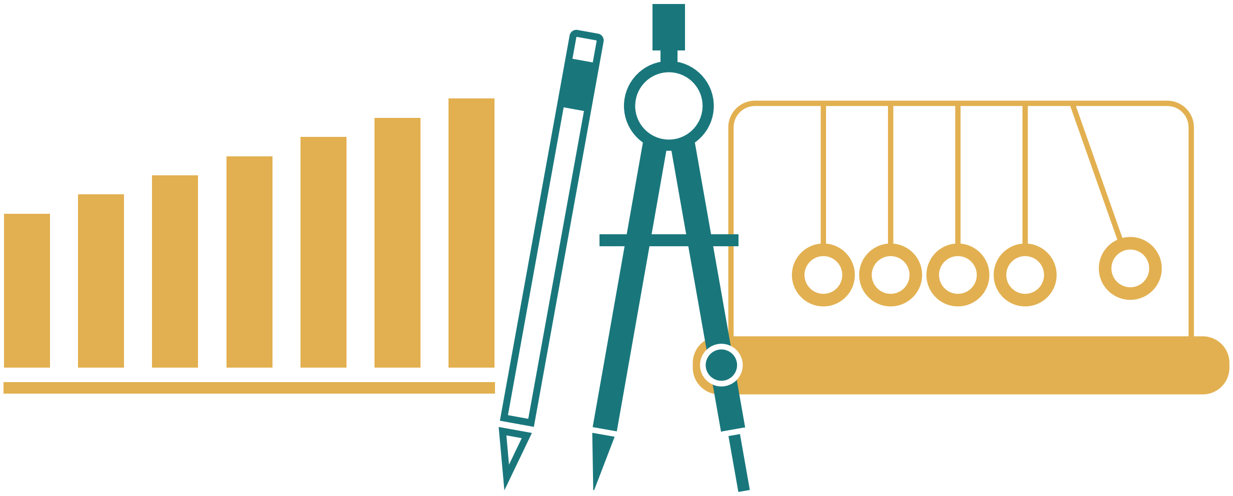


LESSON 5

CALCULATING & COMPARING DENSITY

You've learned how density, mass, and volume are related in your lesson. In this lab, you will have a hands-on opportunity to calculate and compare the densities of four different cylinders using their mass and volume.

Supplies

- 25 or 50 mL graduated cylinder
- Electronic scale
- Water
- Density cylinders (aluminum, brass, steel, and copper)

Instructions

1. Before you start the lab, write a hypothesis about the density of the four metal cylinders (aluminum, brass, steel, and copper). List them in order from what you think will be the least dense to the most dense and why.
2. Find the mass of the aluminum cylinder by placing it on the electronic scale. Make sure the scale says 0.00 g before placing the cylinder on it. Record the mass of the cylinder in grams in the data table.
3. Fill the graduated cylinder about half full with water (the height of the water should be taller than the metal cylinders. Record the initial volume of the water in milliliters in the data table.

4. Carefully slide the aluminum cylinder into the graduated cylinder. If the graduated cylinder is glass, you may want to tip it (without spilling any water) so that the metal slides down gently.
5. Record the final volume in the graduated cylinder in milliliters in the data table.
6. Calculate the volume of the metal by subtracting the final volume minus the initial volume and record it in the data table.
7. Repeat steps 2-6 with each of the three remaining metals.

Hypothesis

___

___

___

___

___

Data Table

Metal	Mass of metal	Initial volume of water	Final volume of water + metal	Volume of metal (Subtract final volume - initial volume)	Density of metal
Aluminum					
Brass					
Steel					
Copper					

Questions

1. Calculate the density for each of the metals below using the mass and volume from your data. Record your final answers in the data table. (Use A-P-C-E to solve!)

   a. Aluminum

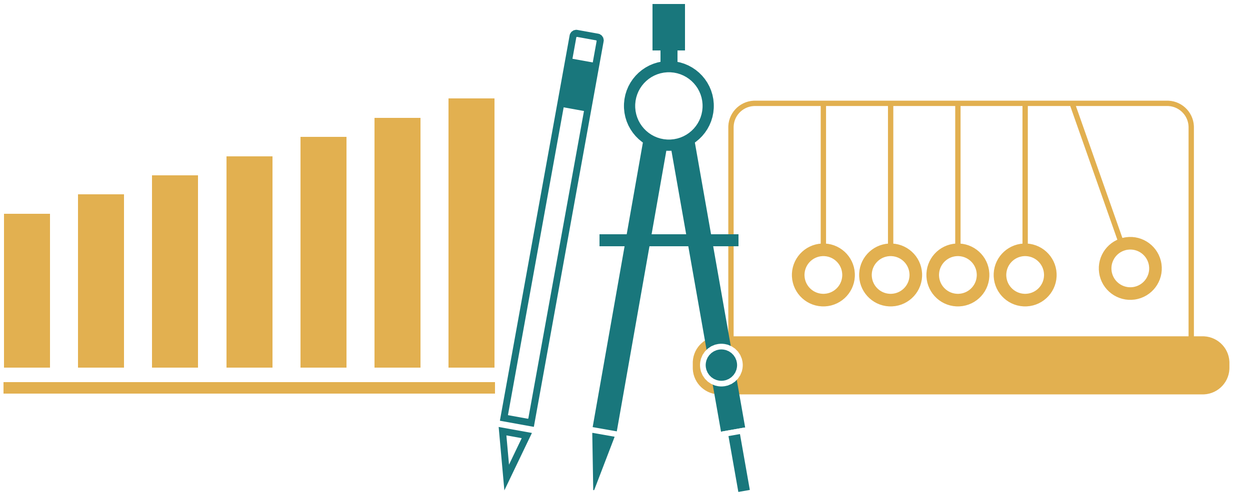
   b. Brass

   c. Steel

d. Copper

2. Based on your data, list the metals from least dense to most dense. Was your hypothesis correct? Why or why not?

3. What do you think would happen to the densities if we doubled the amount of metal in the cylinders? Why?



LESSON 6

BUILDING BOHR MODELS

We use Bohr models to give us a visual of the relative location and number of protons, neutrons, and electrons in an atom. In this lab, you will get to practice making Bohr models using different colored candies (or other small objects) to represent the different subatomic particles.

Supplies

- String
- Colored pencils
- M&Ms (alternative: beads, legos, or other small objects)
- Periodic table

Instructions

1. Choose three different colors of M&Ms to represent the three different subatomic particles and fill in the key below by shading in each box to match the colors you choose.
2. Lay a piece of string in the shape of a circle on the table to represent your nucleus.
3. Using your periodic table, determine how many protons, neutrons, and electrons are in an atom of beryllium. Record in the data table.
4. Place the correct number of M&Ms in the nucleus to match the numbers of protons and neutrons.

   Example: If an atom had two protons and I used blue M&Ms to represent protons, I would place two blue M&M's in the circle. If the atom had three neutrons and I used red M&M's to represent neutrons, I would add three M&M's to the circle.

5. Place more circles of string to represent each energy level needed for the atom.
6. Placing your "electron" M&Ms in pairs, fill the energy levels until your Bohr model is complete.
7. Draw your Bohr model, color coding it with colored pencils. (If protons are blue and there are two protons, write "$2p^+$" in blue).
8. Repeat this process with each of the elements in the data table.

Data Table

Key: ▢ = Protons ▢ = Neutrons ▢ = Electrons

Element info	Bohr model drawing
Beryllium p^+ = ______ n^o = ______ e^- = ______	
Sodium p^+ = ______ n^o = ______ e^- = ______	
Nitrogen p^+ = ______ n^o = ______ e^- = ______	
Phosphorus p^+ = ______ n^o = ______ e^- = ______	
Potassium p^+ = ______ n^o = ______ e^- = ______	

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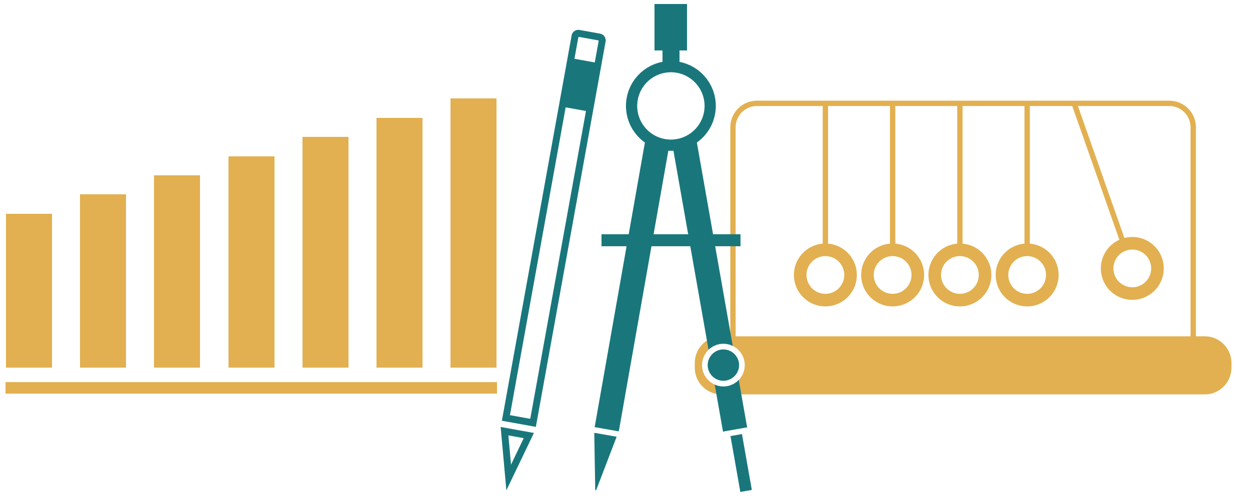

LESSON 7

RESEARCH YOUR FAVORITE ELEMENT

Now that you've learned a little bit about the periodic table and some of the information it provides, it's time to do your own research on an element that interests you!

Instructions

1. Pick an element that interests you.
2. Fill in the chart on the next page with information about that element. Some pieces of information you can get from the periodic table, others you'll need to find from a reliable source.

Element name	
Discovered by (scientist name)	
Date discovered	
Where it is found in nature or what do we use it for	
Description/properties (color, state of matter, safety info, etc.)	
Fun/cool fact about element	
Nuclear notation	
Hyphen notation	
Protons	
Neutrons	
Electrons	
Average atomic mass	
Molar mass	

Mass number	
Period number	
Group number	
Valence electrons	
Ion charge	
Bohr model	
Other information (optional)	

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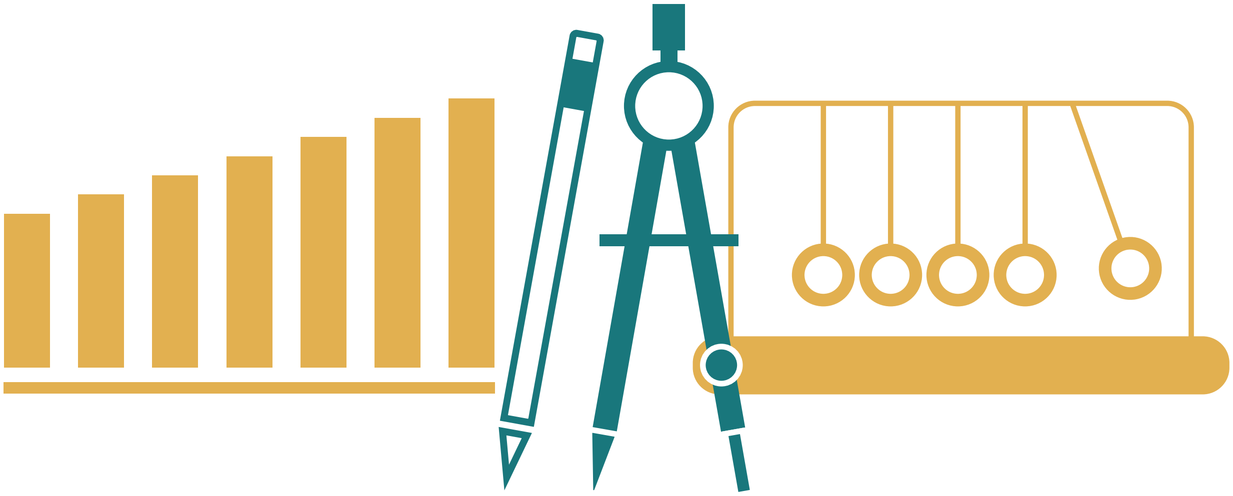


LESSON 8

EXPLORING PROPERTIES OF IONIC & MOLECULAR COMPOUNDS

Ionic compounds contain ionic bonds and molecular compounds contain covalent bonds. By examining how these substances melt and dissolve in different solvents, you'll uncover the effects of ionic and covalent bonding. Discover how each type of compound reacts to heat and solvents and see chemistry in action!

Supplies

- Disposable aluminum pie pan
- Water
- Well plate
- Sodium chloride (table salt)
- 2 droppers
- Ethanol
- Calcium chloride
- Sugar
- Candle wax (scrape a small amount off of any household candle)
- Sharpie marker

Instructions

1. Place a small amount of calcium chloride, candle wax, sodium chloride, and sugar on an aluminum pan. Label each substance on the aluminum pan using a Sharpie marker.
2. Record initial observations for each of the substances in the table below. Note the color and consistency of each substance.
3. Place the pan on one of the burners on your stove and turn the burner on medium-low heat.
4. In the melting point column, record the order that the substances melt in the table below. Place a 1 next to the first substance that melts, a 2 next to the second, and so on.
5. After 2-3 minutes, turn off the burner and record an "N" in the melting point column for any of the substances that did not melt. Allow the setup to cool until the lab is complete.
6. Place a few crystals of each substance in different spots on your well plate.
7. Add about 10 drops of water to each substance. Do not stir. If the substance dissolves, write "yes" in the data table. If it does not, write "no."
8. Wash and dry your well plate, then repeat steps 6-7 with ethanol instead of water.
9. Research if a solution of each of these substances will conduct electricity and record your findings in the table below.

Data Table

Compound	Initial observations	Melting point	Dissolves in water?	Dissolves in ethanol?	Conducts electricity?
Calcium chloride ($CaCl_2$)					
Candle wax ($C_{25}H_{52}$)					
Sodium chloride (NaCl)					
Sugar ($C_{12}H_{22}O_{11}$)					

Questions

1. Group the test substances into two groups according to the properties you observed in the lab. Label one "Group 1" and the other "Group 2."

____

____

2. List the properties of each group based on your observations.

____

____

____

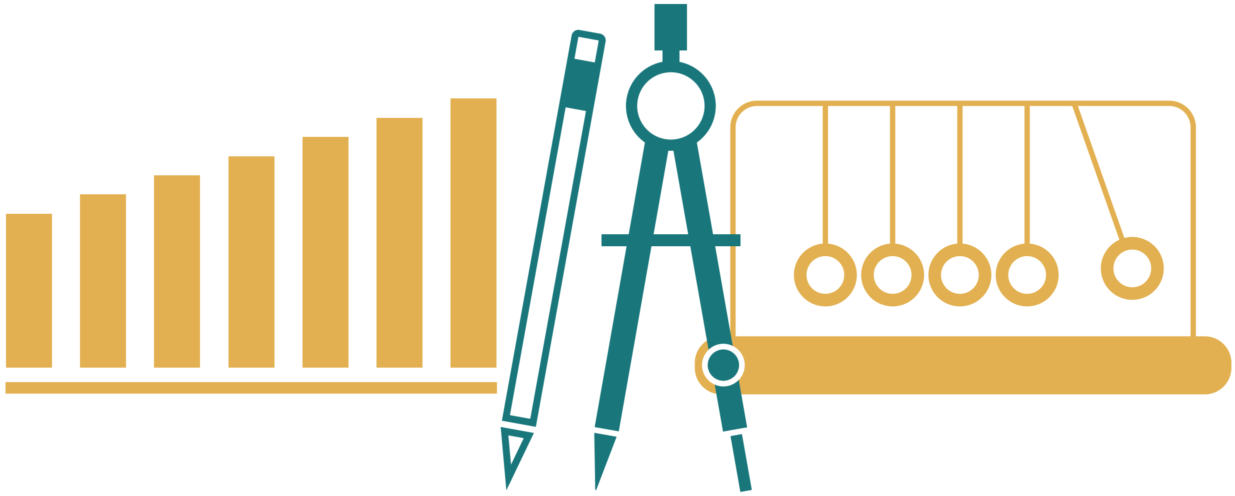
____

3. Write a statement to summarize the properties of ionic compounds and another statement to summarize the properties of covalent compounds.

4. If a compound has a high melting point, is soluble in water, and conducts electricity, what types of bonds do you expect the compound to have? Use an example from the lab to back up your claim.

5. Which group from question #1 do you think contained ionic bonds and which contained covalent bonds?

6. Did every test support your answer in question #5 for each substance (for example, did any ionic compounds melt faster than covalent ones)? What might be a reason for results you didn't expect?



LESSON 10

GROWING IONIC CRYSTALS

Epsom salt is the common name for the chemical compound magnesium sulfate. It's a naturally occurring mineral with properties that allow it to be used to help all sorts of human ailments—from muscle aches to stress reduction. You won't be using Epsom salts for health reasons in this lab, but you will use them to grow ionic crystals.

Supplies

- 1/2 cup magnesium sulfate
- Hot water
- 250 mL beaker, half-pint mason jar, or similar-sized glass dish
- Food coloring (optional)
- Spoon

Instructions

1. Observe a spoonful of magnesium sulfate. Consider what their appearance is, then write your observations and draw a picture of what they look like in the sketch box below.
2. Add ½ cup of magnesium sulfate to the beaker.
3. Carefully add ½ cup of hot water to the beaker and stir for at least one minute. There may be some undissolved crystals at the bottom of the beaker (this creates a saturated solution, meaning no more salt can dissolve in the water).
4. Add a few drops of food coloring if you want your crystals to be colored.
5. Put the beaker in the refrigerator for 3 hours.

6. Carefully pour out the remaining liquid and examine the crystals left behind. Draw a picture in the sketch box below and write down your observations.

MAGNESIUM SULFATE

MAGNESIUM SULFATE CRYSTALS

Questions

1. What is the chemical formula of magnesium sulfate?

2. How did the magnesium sulfate you dissolved differ from the crystals you ended up with?

3. Based on what you know about ionic compounds, why do you think these crystals were able to form?

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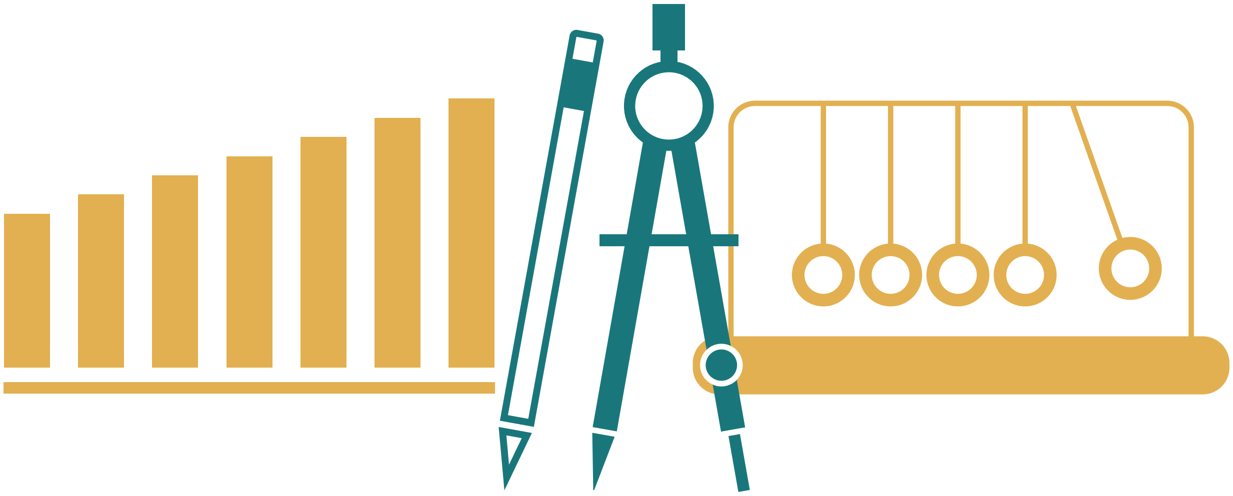

LESSON 11

IONIC COMPOUNDS DICE

This lab is all about practice, practice, practice. Using a simple dice game, we will see how different ions can combine to form a variety of compounds, and we can practice our new skills of writing formulas and compound names.

Supplies

- 2 dice
- Masking tape
- Marker

Instructions

1. Cover all six sides of one die with masking tape. Use a marker to write the element symbol and charge for the following ions, so one ion is on each side: K^+, Mg^{2+}, Cu^{2+}, Fe^{3+}, Al^{3+}, Pb^{4+}.
2. Cover all six sides of another die with masking tape. Use a marker to write the ion symbol and charge for the following ion, so one ion is on each side: Cl^-, F^-, O^{2-}, N^{3-}, $(SO_4)^{2-}$, $(PO_4)^{3-}$.
3. Roll the dice and record the symbol on each die in the data table below.
4. Cross the charges and reduce if necessary to determine the chemical formula for the compound formed between those two ions and record in the data table below.
5. Write the correct name for this compound in the data table below.
6. Repeat until the data table is full. If you roll the same compound more than once, reroll the dice until a new compound is formed.

Data Table

Cation symbol	Anion symbol	Chemical formula	Compound name

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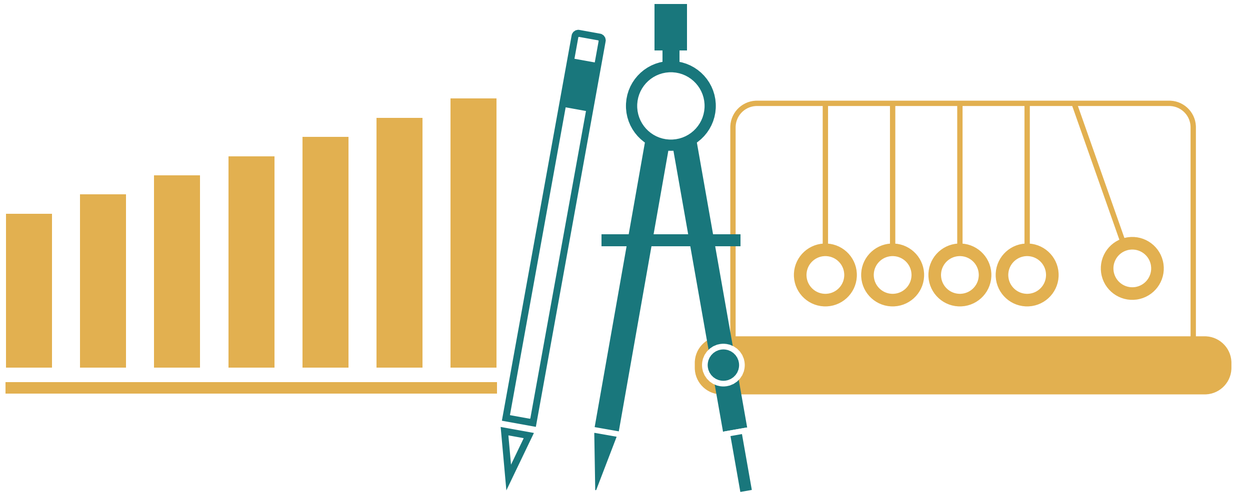

LESSON 12

DECODING COVALENT COMPOUNDS

Many covalent (molecular) compounds are found in nature or are very useful in various industries. In this lab, you will discover more about some of these compounds as you practice naming and writing formulas for them.

Instructions

Fill in the chart on the next page with the missing information. The names and formulas you should do on your own. The other information you can find from a reliable source.

Data Table

Name	Chemical formula	Properties	Uses
Phosphorus pentachloride			
Sulfur dioxide			
Bromine pentafluoride			
	N_2O		
	P_4O_{10}		
	ClF_3		

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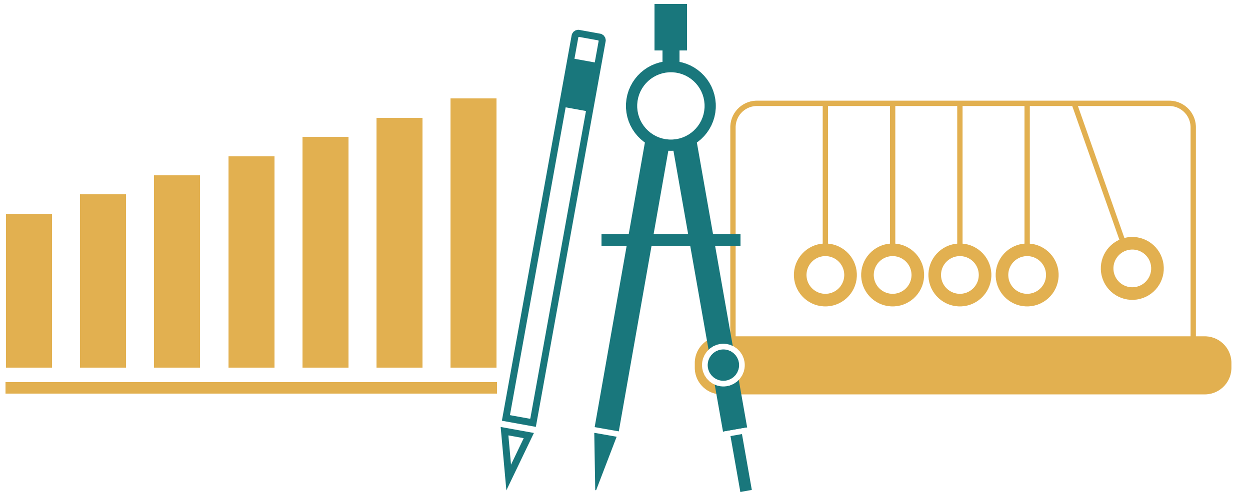

LESSON 13

BALANCING ACT: USING M&MS AND ALKA SELTZER TO INVESTIGATE CHEMICAL REACTIONS

In part 1 of this lab, you will use M&Ms to practice balancing chemical equations. This hands-on (and tasty) lab will help you visualize how atoms move around. You'll then use a common cure for heartburn and indigestion to help you explore the law of conservation of mass.

Supplies

Part 1:

- Colored pencils
- M&Ms— four colors, 20 of each color

Part 2:

- Scale
- Graduated cylinder
- Alka-Seltzer® tablet
- 12 oz plastic bottle with cap

Instructions

Part 1: Balancing Equations With Candy

1. On a separate piece of paper, write each of the following equations at the top of a sheet of paper:

$NaCl$	I_2	→	NaI	Cl_2
Na_2S	HCl	→	H_2S	$NaCl$
Al	Br_2	→	$AlBr_3$	
Ni_2O_3		→	Ni	O_2
Al	ZnO	→	Al_2O_3	Zn

2. Use M&Ms placed on your paper to represent atoms in each of the equations.
3. Change coefficients to balance the equation, and adjust the M&Ms accordingly.
4. When the equation is balanced, use colored pencils to draw the atoms and molecules represented by the M&Ms.
5. After all of the equations are balanced, enjoy eating your M&Ms!

Part 2: Conservation of Mass With Alka-Seltzer

1. Measure 200 mL of water and carefully pour it into the empty plastic bottle, then put the cap back on the bottle.
2. Put the closed bottle with water and half an Alka-Seltzer tablet on the scale and record the mass on the data table.
3. Open the bottle, drop the Alka-Seltzer tablet in, and immediately close the lid very tightly. Note any changes that take place.
4. Wait until the tablet has completely dissolved. Place the closed bottle on the scale and record the mass on the data table.
5. Slowly uncap the bottle and let it sit for 30 seconds. Then recap the bottle.
6. Being careful not to spill, place the filled bottle and cap back on the scale. Record the mass on the data table.

Data Table

Mass before reaction	Mass after reaction	Mass after uncapping

Questions

1. Did a chemical change occur during this experiment? How do you know?

   ____

2. Was the mass of the system after the reaction the same as the mass of the system before the reaction? Try to explain why or why not.

   ____

3. Was the mass of the system after uncapping the same as the mass of the system before the reaction? Try to explain why or why not.

   ____

   ____

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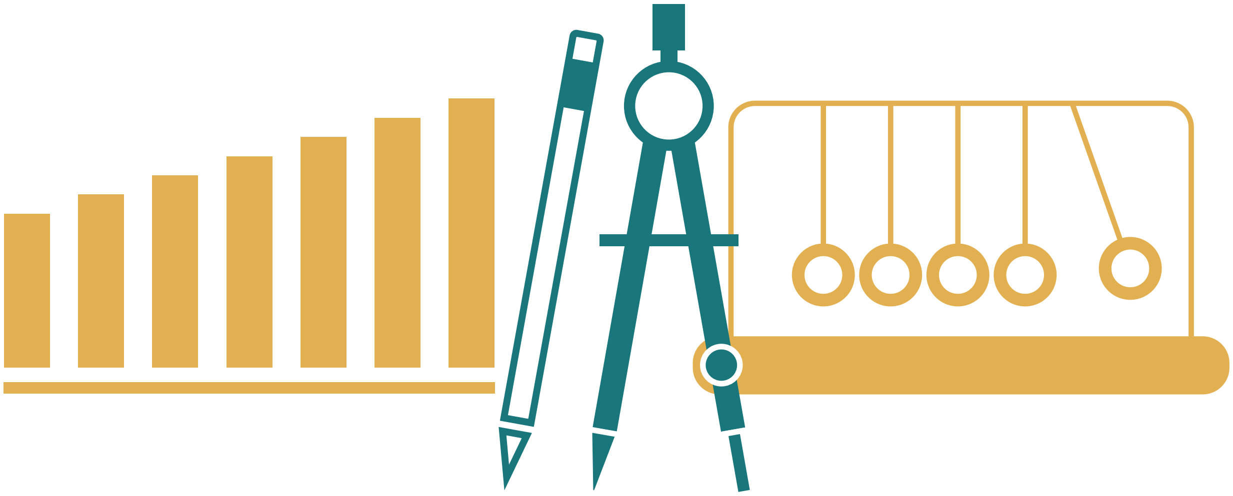

LESSON 14

CHEMICAL REACTIONS IN ACTION

Now that you know the different types of chemical reactions, you'll have the opportunity to see each of them in action! From the explosive fizz of "elephant toothpaste" to the color changes in metal and the formation of precipitates, you'll investigate how different types of reactions unfold in a series of hands-on experiments.

Supplies

Part 1

- 1 packet (1 Tbsp) dry yeast
- Small container
- 3 Tbsp warm water
- Spoon
- 25 mL or 50 mL graduated cylinder
- Dish soap
- Food coloring
- Hydrogen peroxide (6% is ideal but 3% will also work)
- Tray or baking sheet (something to catch the foam that overflows)

Part 2

- Copper(II) sulfate
- Disposable pipette
- Steel wool
- 2 beakers

Part 3

- Copper(II) sulfate
- 2 beakers
- Dilute sodium hydroxide
- Disposable pipette

Part 4

- Steel wool
- Bowl
- Vinegar

Instructions

Part 1: Elephant Toothpaste

1. Pour 10 mL hydrogen peroxide into your graduated cylinder and place it on a tray or baking sheet.
2. Add 3-5 drops of food coloring.
3. Add several drops of dish soap into the cylinder and swirl around to mix.
4. In a separate small container, mix yeast and warm water for about 30 seconds.
5. Pour the yeast/water mixture into the graduated cylinder and record your observations below.
6. After the reaction is complete, it can be disposed of by washing down the kitchen sink with water.

Questions

1. Record your observations from the reaction (what you see, hear, and feel).

____

____

____

2. The chemical equation for this reaction is $H_2O_2 \xrightarrow{\text{yeast}} H_2 + O_2$. "Yeast" is over the arrow because it is a catalyst: it does not react, but it helps the reaction to occur more quickly, so it can be ignored when categorizing and balancing the equation. What type of reaction is this?

____

Part 2: Iron + Copper(II) Sulfate

1. Add a small amount of steel wool to the bottom of a small beaker or test tube (it doesn't matter how much, as long as it fits!)
2. Make a copper(II) sulfate solution.
   a. Pour 10 mL of water in a small beaker.
   b. Measure 0.25 g of copper(II) sulfate on a scale and add to the small beaker.
   c. Gently stir until the copper(II) sulfate has dissolved in the water.
3. Carefully add 4-5 mL of copper(II) sulfate to the test tube, enough to cover the steel wool. Save the remainder of your copper(II) sulfate solution for Part 3.
4. Let the mixture sit for up to 10 minutes and record your observations below.
5. After the reaction is complete, it can be disposed of by throwing it in the trash can.

Questions

1. Record your observations from the reaction (what you see, hear, and feel).

   ____

   ____

   ____

2. The chemical equation for this reaction is $Cu(SO_4) + Fe \rightarrow Fe(SO_4) + Cu$. What type of reaction is this?

   ____

3. Based on the equation above, what do you think the reddish substance on the steel wool is?

   ____

Part 3: Copper(II) Sulfate + Sodium Hydroxide

1. Add 10-15 drops of copper(II) sulfate solution to a beaker.
2. Make a dilute sodium hydroxide solution.
   a. Pour 10 mL of water in a small beaker.
   b. Measure 0.25 g of sodium hydroxide and add to the small beaker.
   c. Gently stir until the sodium hydroxide has dissolved in the water.
3. Carefully add 10-15 drops of sodium hydroxide to the beaker with the copper(II) sulfate solution.
4. Gently swirl the test tube and record your results below.
5. After the reaction is complete, it can be disposed of by washing down the kitchen sink with water.

Questions

1. Record your observations from the reaction (what you see, hear, and feel):

   ____

   ____

   ____

2. The equation for this reaction is $CuSO_4 + 2\ NaOH \rightarrow Na_2SO_4 + Cu(OH)_2$. What type of reaction is this?

   ____

3. Think back to the signs that a chemical change has occurred. How do you know this is a chemical reaction?

   ____

Part 4: Steel Wool & Oxygen

1. Soak a small amount of steel wool in a bowl of vinegar for several minutes. (This is not part of the reaction, it just removes the coating on the steel wool to allow the reaction to take place.)
2. Remove the steel wool and let it sit out for several hours (or overnight) and record your observations below.
3. After the reaction is complete, it can be disposed of by throwing it in the trash can.

Questions

1. Record your observations from the reaction (what you see, hear, and feel).

____

____

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2. The equation for this reaction is $4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$. The wool has reacted with oxygen in the air overnight. What type of reaction is this?

____

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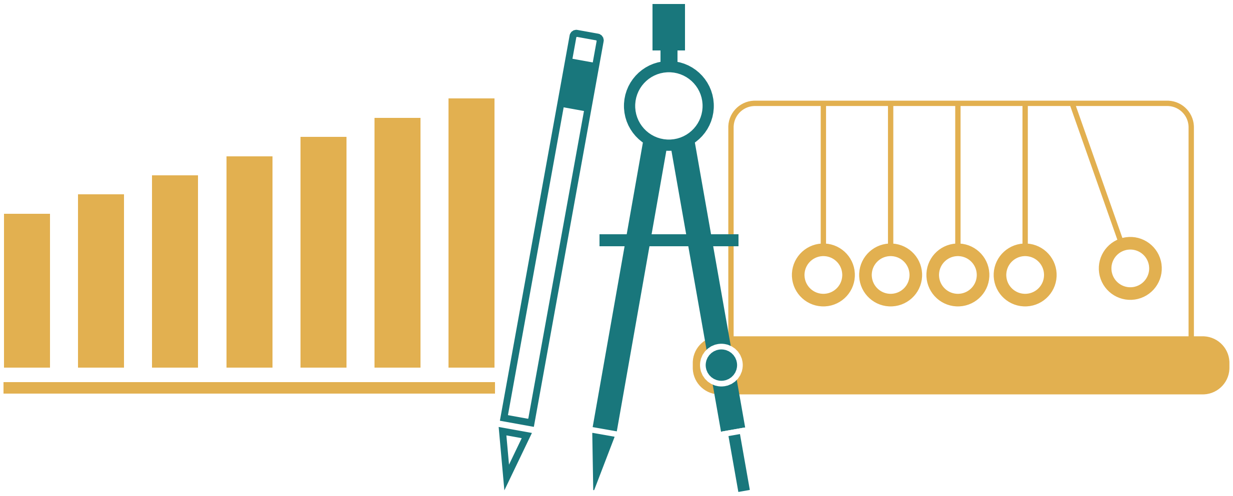

LESSON 15

SOLUBILITY OF EPSOM SALTS & SODIUM CARBONATE

In this lab, you'll discover the science of solubility by exploring how common substances dissolve in water. Using simple tools to measure and mix magnesium sulfate (Epsom salts) and sodium carbonate, you will be able to observe how each of these substances dissolves and how their solutions interact.

Supplies

- 25 or 50 mL graduated cylinder
- 250 mL beaker
- 3.00 g sodium carbonate
- Scale
- 2 - 100 mL beakers
- 3.00 g magnesium sulfate
- 2 spoons

Instructions

1. Place a 100 mL beaker on the scale and zero (tare) it. Carefully measure out 3.00 g of magnesium sulfate in the beaker.
2. Measure 50 mL of water using the graduated cylinder.
3. Take the beaker off the scale and slowly add 50 mL of water to the beaker. Stir until the magnesium sulfate is dissolved.

4. Place an empty 100 mL beaker on the scale and zero it. Carefully mass out 3.00 g of sodium carbonate in the beaker.
5. Measure 50 mL of water using the graduated cylinder.
6. Take the beaker off the scale and slowly add 50 mL of water to the beaker. Stir until the sodium carbonate is dissolved.
7. Pour about half of the magnesium sulfate into the 250 mL beaker, then carefully add about half of the sodium carbonate to the third beaker. Record your observations.
8. After you have completed your lab, the solutions may be washed down the kitchen sink with water.

Questions

1. Is magnesium sulfate soluble in water? Why or why not?

___

2. Calculate the molarity of the magnesium sulfate solution (3.00 g of magnesium sulfate = 0.025 mol). HINT: How much water did you use to make the solution?

3. Is sodium carbonate soluble in water? Why or why not?

___

4. Calculate the molarity of the sodium carbonate solution (3.00 g of sodium carbonate = 0.028 mol). HINT: How much water did you use to make the solution?

5. Which of the two solutions is stronger or more concentrated? How do you know?

6. Is the product of the reaction between magnesium sulfate and sodium carbonate soluble in water? Why or why not?

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LESSON 16

ACIDS & BASES IN YOUR HOME

Testing pH with pH paper allows us to easily see the strength of acids and bases of different substances. pH paper changes color for every whole number. In this lab, you will have the opportunity to use pH paper for yourself to test the pH of common substances throughout your home to see whether they are acids or bases!

Supplies

- pH paper
- 10 substances found around your house

Instructions

1. For each substance, record a hypothesis in the table below. Do you think your substance is an acid, base, or neutral?
2. If the substance you choose is a solid or powder, dissolve a small amount in water.
3. Dip a strip of pH paper in your first substance. It should change color immediately.
4. Compare the color of the paper to the pH chart on the tube and record the pH value in the table below.
5. Repeat this process for each of the other substances.
5. **If the substance is safe to eat**, taste it and see if the taste matches your observations! If it's an acid, is it sour? If it's a base, is it bitter?

Data Table

Substance	Hypothesis	pH	Acid or base?

Questions

1. Which of the substances that you tested were acids?

2. Which of the substances that you tested were bases?

3. Did the pH of any of the substances surprise you? Why or why not?

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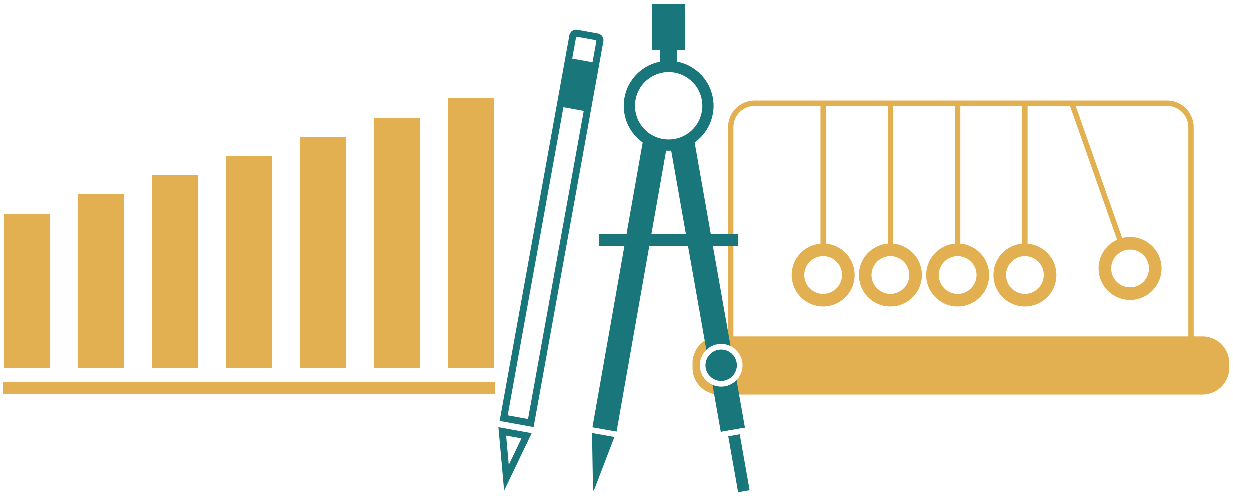

LESSON 17

THE HALF-LIFE OF RADIOACTIVE PENNIES

A radioactive element's half-life is the amount of time it takes for one-half of an unstable element to change into another element or a different form of itself. In this lab, you will use pennies to simulate radioactive decay and explore the concept of half-lives.

Supplies

- 128 pennies
- Jar with lid
- Flat work surface

Instructions

1. Place 128 pennies in a jar and place the lid on the jar. These pennies will represent 128 radioactive elements of the same kind.
2. Shake the jar, then pour the pennies onto a flat work surface.
3. Separate pennies that are heads up from those that are tails up. Count and record the number of heads-up pennies and set these pennies aside. Place the tails-up pennies back in the jar.
4. Repeat the process until all of the pennies have been set aside.

Data Table

Trial #	Heads-up pennies
0	128
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

Questions

1. What did the pennies represent in this lab?

2. What did one trial represent?

3. Theoretically, how much of the sample should have "decayed" with each trial?

4. Was this true for every trial? If not, why do you think that happened?

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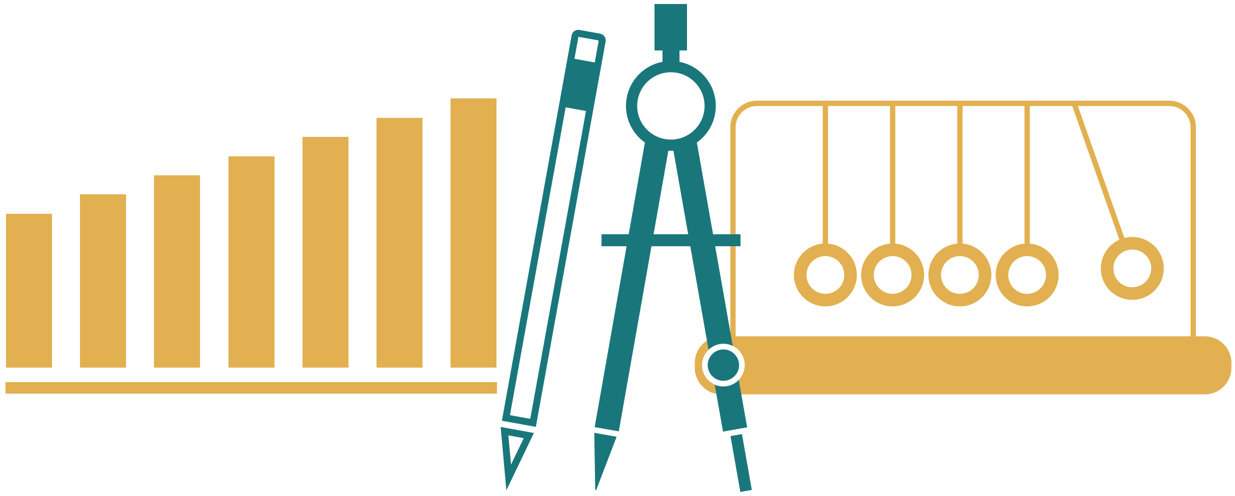

LESSON 19

SPEED TEST: CALCULATING VELOCITY

In this lab, we will put your understanding of velocity to the test. Measure your running speed over a set distance and calculate your velocity using real-time data. By racing against the clock and analyzing your results, you'll gain practical insights into how velocity is determined and applied in everyday scenarios.

Supplies

- Stopwatch
- Tape measure (metric preferred)
- Sidewalk chalk, tape, or rope

Instructions

1. In a safe, open area outside, use sidewalk chalk or tape to draw a starting line. From the starting line, walk a minimum of 30 steps forward and draw a finish line.
2. With your measuring tape, measure the distance between the two lines in meters to the nearest hundredth of a meter and record in the data table for all three trials. If you do not have a way to measure in meters, you can use an online tool to convert from feet or inches to meters.
3. Stand at the starting line. Have a family member record the time it takes for you to run from the starting line to the finish line. Record the time in the data table.
4. If possible, have two other family members or friends complete step 3. If not, you can repeat

step 3 two more times yourself.

Data Table

Person (or Trial #)	Distance	Time

Questions

1. Calculate the average speed for each of the three trials.

2. Who (or which trial) had the fastest speed? Use your definition of speed to explain why.

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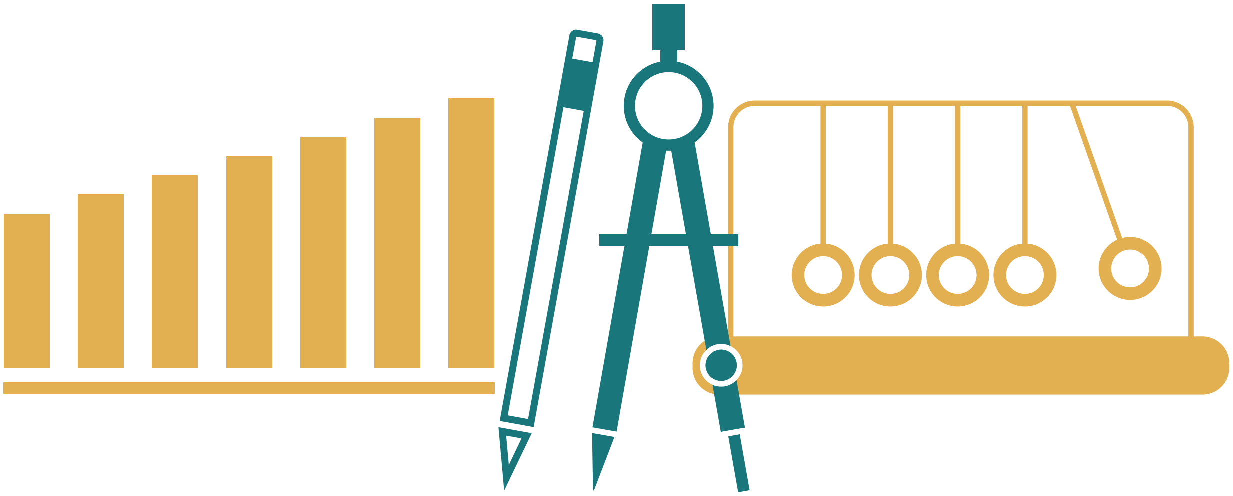


LESSON 20

DOWNHILL DYNAMICS: ANALYZING ACCELERATION WITH A TOY CAR

In this lab, you'll apply what you've learned about velocity and acceleration as we complete a simulation of a toy car moving down a hill. You'll measure how its speed changes to allow you to observe these principles in action.

Supplies

- Toy car
- Stopwatch
- Tape measure (metric preferred)
- Ramp (cardboard or wooden board)
- Sharpie

Instructions

1. In a clear space, create a ramp that's at least 2 m long using a large piece of cardboard or a wooden board. Use books or other materials to elevate your ramp about 15 cm off the ground.
2. Mark two lines on the ramp with tape or a Sharpie marker. One mark should be about 1/3 of the way down the ramp and the other should be about 2/3 of the way down the ramp.

3. Measure distances in meters. If you do not have a way to measure in meters, you can use an online tool to convert from feet or inches to meters.
    a. Measure the distance from the top of the ramp to the bottom of the ramp.
    b. Measure the distance from the higher mark to the bottom of the ramp.
    c. Measure the distance from the lower mark to the bottom of the ramp.
    d. Record these distances on the data table.
4. Hold the toy at the top of the ramp. When you're ready, start the timer while letting go of the toy. Stop the timer as soon as the toy reaches the bottom of the ramp. Record the time in the data table.
5. Repeat step 4 at the higher mark and the lower mark of the ramp.

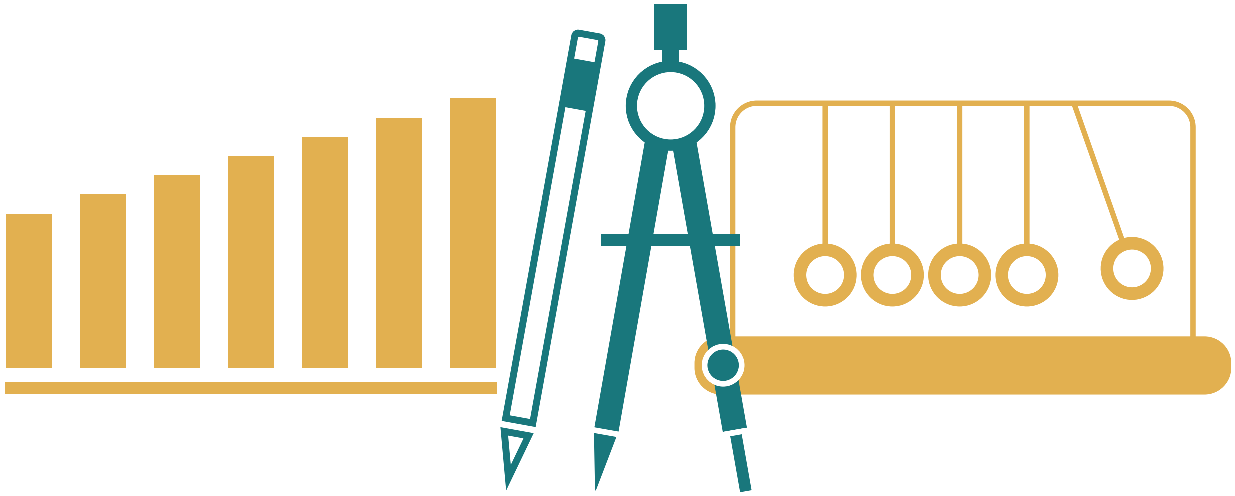
Data Table

Trial	Distance	Time
#1 (Top of ramp)		
#2 (High mark)		
#3 (Low mark)		

Questions

1. Calculate the velocity for each trial.

2. Calculate the acceleration for each of the trials. Remember that each trial started at rest. Use the velocities calculated above as the final velocities.



LESSON 21

THE SCIENCE OF INERTIA

In this lab, we will experience different examples of inertia through a series of mini-experiments using everyday objects you can find around the house. This lab will help you observe how objects resist changes in motion, as you test your hypotheses and see Newton's first law of motion come to life.

Supplies

- Cup
- Index card
- 5 pennies
- 5 quarters
- 2 objects with noticeably different masses (ex: bowling ball and ping pong ball)
- Tablecloth, table, and dishes (preferably non-breakable, but sturdy)

Instructions

1. For each station, write a hypothesis for what you think will happen.
2. Perform the experiment and record your observations. Was your hypothesis correct?

Station 1

1. Place an index card flat over the cup, making sure an edge of the index card hangs over the ledge of the cup.
2. Place a penny on the index card so it is centered over the cup.
3. Record your hypothesis in the data table writing what you think will happen when you flick the index card.
4. Quickly flick the edge of the index card sideways with your finger. Make sure you do not flick it up or down by having your hand above or below the index card.
5. Record your observations in the data table.

Station 2

1. Bend the elbow of your dominant hand so your palm is next to your ear, facing up toward the ceiling.
2. Place a penny on the top of your elbow.
3. Record your hypothesis on the data table writing what you think will happen when you drop your elbow and try to catch the penny.
4. Drop your elbow and straighten your arm to try to catch the penny with your dominant hand.

Station 3

1. Stack four quarters on top of each other on a smooth surface, such as a table.
2. Record your hypothesis on your data table writing what you think will happen when you flick the 5th quarter flat across the table at the stack of quarters.
3. Flick the quarter at the stack and record your observations in the data table.

Station 4

1. Gather the two objects with different masses and record your hypothesis on the data table writing what you think will happen when you shake each object.
2. Pick up each object individually and try to shake them vigorously.
3. Record your observations.

Station 5

1. Put a tablecloth over a table.
2. Set the dishes on the table, leaving room at the edge of the table.
3. Record your hypothesis on the data table writing what you think will happen when you try to pull the tablecloth off the table.
4. Grab the edge of the tablecloth with both hands and quickly pull it toward you and away from the table.
5. Record your observations in the data table.

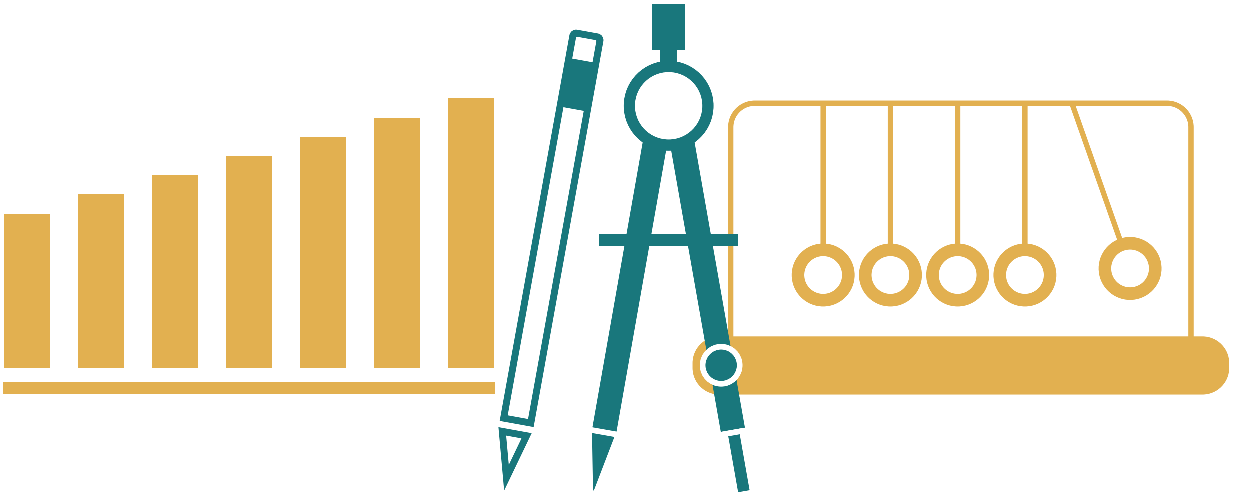
Data Table

Station #	Hypothesis	Observations	Hypothesis correct? (Yes or No)
1			
2			
3			
4			
5			

Questions

1. What did each of these stations have in common? Write a paragraph to explain how they relate to what we've been learning.

2. If you designed a station to test inertia similar to the ones we did here, what would you do? If you have the materials, try it out and record your observations!



LESSON 22

THE DYNAMICS OF FALLING OBJECTS: UNDERSTANDING GRAVITY & AIR RESISTANCE

Explore the forces of gravity and air resistance with a series of experiments using common household objects. These activities will give you an inside look at how gravity and air resistance impact falling objects. See how these fundamental forces play out in everyday contexts!

Supplies

- 2 small balls with different masses (tennis ball, ping pong ball, baseball, etc.)
- Piece of paper
- Paper napkin
- Tape
- Stopwatch
- String or yarn
- Large paperclip

Instructions

Part 1: Two balls of different masses

1. Write a hypothesis for what you think will happen when you drop two balls of different masses from the same height at the same time. Which will land first and why?
2. Hold the two balls so that the bottom of each ball is at the same height.

3. Drop both balls at the exact same time and record your observations.

Hypothesis: ____

____

____

Observations: ____

____

____

Part 2: Ball & a piece of paper

4. Write a hypothesis for what you think will happen when you drop one of the balls and a piece of paper from the same height at the same time.
5. Hold the ball and a piece of paper so the paper is at the same height as the bottom of the ball.
6. Drop both objects at the exact same time and record your observations.

Hypothesis: ____

____

____

Observations: ____

____

____

Part 3: Ball launch vs. ball drop

7. Find a table or other flat surface with a ledge.
8. Write a hypothesis for which will make a ball fall more quickly— rolling it off the edge of the table or dropping it straight down from the height of the table.

9. Measure the table you'll be using and record the measurement in meters on the data table.
10. You may need a partner or a video camera for this experiment.
    a. If using a partner, one person should roll/drop the ball, and the other should start and stop the stopwatch.
    b. Alternatively, you may set up a smartphone to film the ball in slow motion along with a timer. Calculate the amount of time it took based on the times shown in the video.
11. Roll the ball off the edge of the table. Start the stopwatch as soon as the ball leaves the table's surface. Stop the stopwatch as soon as the ball hits the ground. Record the time in the data table.
12. Hold the ball so the bottom of the ball is at the same height as the surface of the table.
13. Drop the ball and start the stopwatch as soon as the ball is dropped. Stop the stopwatch as soon as the ball hits the ground. Record the time in the data table.
14. Using the height of the table and the time, calculate the velocity of each ball. Record your observations.

Hypothesis: ____

____

____

Data Table

	Height (m)	Time (s)	Velocity
Ball launch			
Ball drop			

Observations: ____

____

____

Part 4: Parachute launch

15. Unfold a paper napkin and lay it flat on a table.
16. Cut four pieces of string into equal lengths, approximately 6-8 inches.
17. Tape a piece of string to each corner of the napkin.
18. Twist the free ends of the pieces of string together.
19. Fold up the twisted ends of the strings to form a loop and secure the loop with a piece of tape.
20. Hook the paperclip through the loop. You have now made a parachute.
21. Write a hypothesis for what will happen when you drop the parachute from a tall height (what will the motion of the parachute look like when you first drop it halfway down and as it hits the ground?).
22. Find a safe, high, launching location such as a flight of stairs, balcony, or ladder. Look for a launching location that is a minimum of 10 feet high, but the higher the better!
23. To launch your parachute, pinch the top in the middle of the parachute, hold it up, and release it.
24. Record your observations.

Hypothesis: ____

____

____

Observations: ____

____

____

Questions

1. Were your hypotheses correct? Why or why not?

2. How did you see the effects of gravity in this experiment?

3. How did you see the effects of air resistance in this experiment?

4. How could you change these experiments to further your exploration of gravity and air resistance? Or what are some other experiments you could try?

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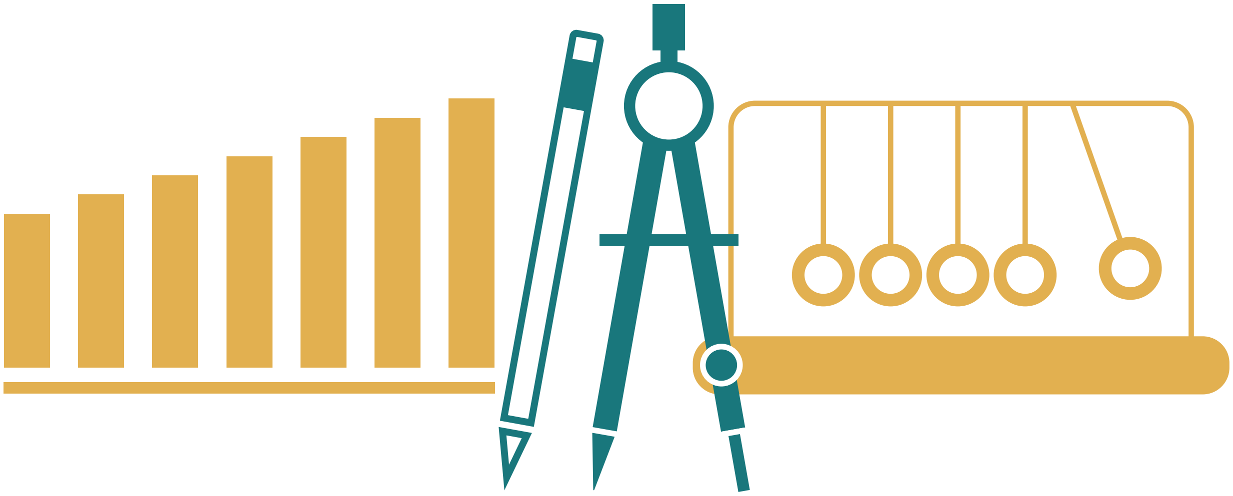

LESSON 23

SLINGSHOT SCIENCE: EXPLORING FORCES & MOMENTUM

In this lab, you will build a simple slingshot that will allow you to further explore Newton's third law of motion and momentum. Get ready to launch projectiles and witness the fascinating interplay of forces!

Supplies

- 3 cardboard rectangles (10 cm x 15 cm)
- Glue
- String (3-4 inches)
- Marble
- Scissors
- Stopwatch
- Ruler, meterstick, or tape measure
- 3 pushpins
- Rubber band
- Scale
- 6 plastic straws

Instructions

1. Cut pieces of cardboard into three cardboard rectangles measuring 10 cm x 15 cm.
2. Glue the cardboard rectangles together to make a stack of three. Let the glue dry for 5-10 minutes.

3. At one end of the stack, push a pushpin near each corner. These will be the anchors for the rubber band.
4. Make a small loop of string.
5. Place the rubber band over one of the pushpin anchors. Put the rubber band through the loop of string, then place the opposite end of the rubber band over the second anchor (the rubber band should be stretched between the two anchors with the string loop hanging in the middle).
6. Carefully pull the string loop back toward the opposite end of the cardboard stack and anchor it in the middle with the third pushpin.
7. Find and record the mass of the slingshot.
8. Find and record the mass of the marble.
9. Lay the straws parallel to one another on a flat surface. Place the cardboard stack on top of the straws so that the slingshot is perpendicular to the straws (moving the slingshot forward and backward should cause it to roll over the straws).
10. On the lines below, write a hypothesis comparing how you think the motion of the slingshot will compare to the motion of the marble launched from the slingshot.
11. Find a way to mark where the front of the slingshot starts (draw a line or use a piece of masking tape)
12. Place the marble in the center of the slingshot.
13. Carefully cut the string loop, releasing the rubber band.
14. Measure and record the distance the marble traveled from the starting point of the slingshot to where the marble landed.

Hypothesis

____

____

____

____

Data Table

Mass of slingshot	
Mass of marble	
Distance marble traveled	

Questions

1. Which had more mass, the marble or the slingshot?

____

____

____

2. What happened to the slingshot when the marble was launched?

____

____

3. Compare the movement of the marble to the movement of the slingshot. Was your hypothesis correct?

____

____

____

4. Use Newton's third law to explain why the marble and slingshot moved the way they did.

____

____

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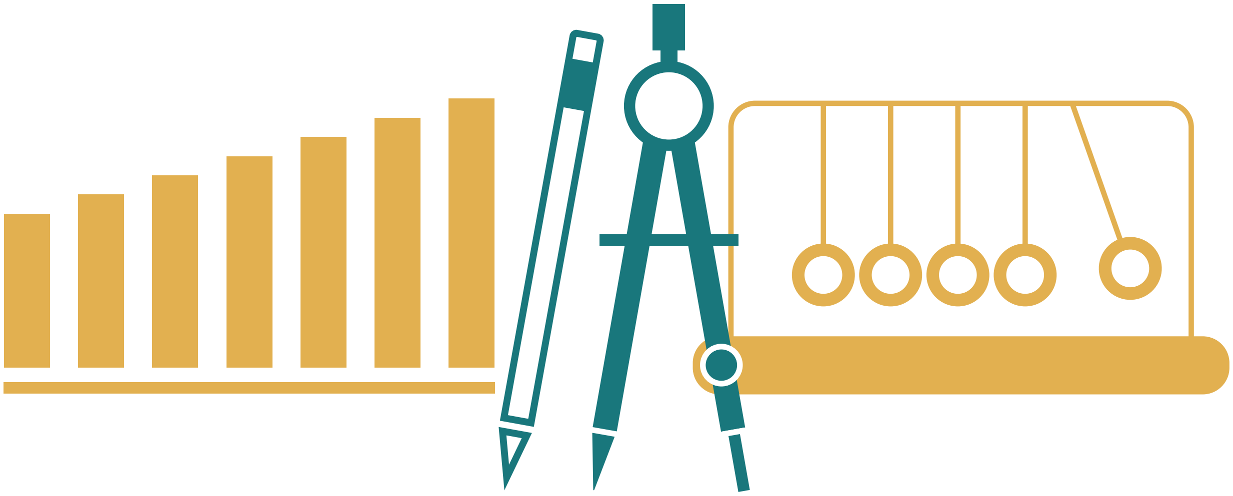

LESSON 24

INVESTIGATING HUMAN WORK & POWER

In this lab, you will conduct a hands-on exploration of the concepts of work and power by lifting a bottle of water off the ground. This experiment will allow you to see how the physics concepts of work and power apply to a real-world scenario.

Supplies

- Scale
- Stopwatch
- Meterstick
- Pole (2-3 cm diameter dowel, ~½ meter long)
- Large bottle filled with water (500 mL - 1 L water or soda bottle)
- Rope/string to tie bottle to dowel with ½-1 m length between

Instructions

1. Measure the mass of your water bottle using the scale. Write the mass in kilograms on your data table.
2. Attach one end of the string to the bottle and the other end to the middle of the pole.
3. Measure the distance of the rope from the pole to the bottle and record it on the data table.

4. Stand on a chair and hold the pole horizontally so the bottle is suspended. Have someone start the stopwatch as you twist the pole so the rope winds around it, lifting the bottle. The person should stop the stopwatch when the bottle is all the way up to the pole.
5. Record the time in seconds it took for you to lift the bottle to the pole in the data table.
6. Repeat this process two more times and record each of your times in the data table. The rest of your data table will remain blank until you answer the questions at the end of the lab.

Data Table

Trial	Mass (kg)	Distance (m)	Time (s)	Force (N)	Work (J)	Power (W)
1						
2						
3						

Questions

1. Calculate the force you used to lift the bottle using the equation Fg = mg and record in the data table.

2. Calculate the work you did to lift the bottle and record in the data table.

3. Calculate the power you used to lift the bottle for each trial and record in the data table.

Trial 1:

Trial 2:

Trial 3:

4. Did the amount of work completed change with each trial? Why or why not?

5. Did the amount of power you used change with each trial? Why or why not?

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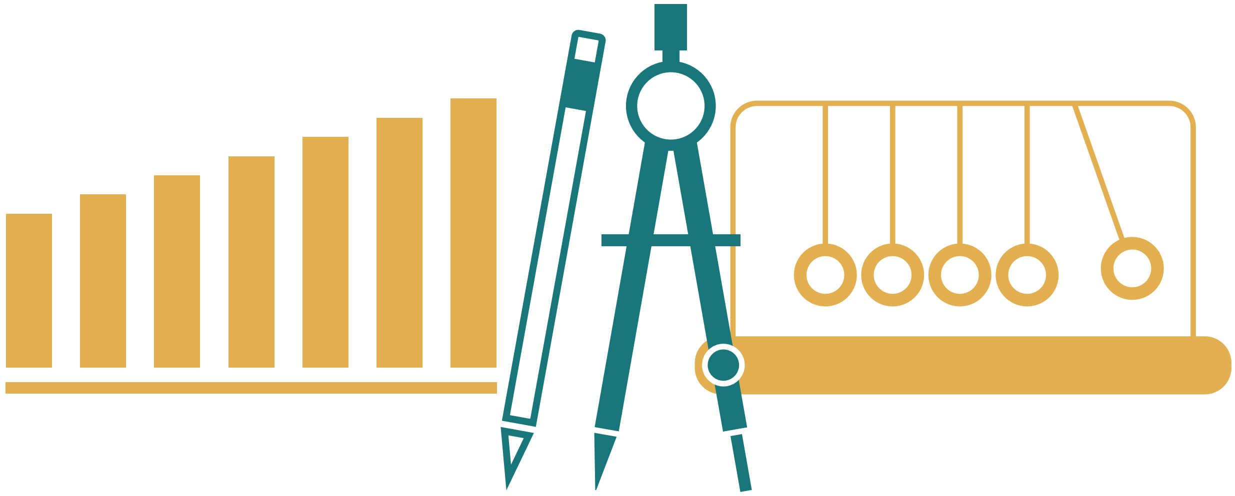

LESSON 25

CONDUCTION CONTEST: COMPARING WIRE CONDUCTIVITY

Get ready to play with fire (safely, of course) in this lab where you'll be using wires and wax to learn about heat conduction. Which wire do you think will melt the wax the fastest?

Supplies

- Candle
- Lighter or matches
- Stopwatch
- 30 cm - 8 gauge aluminum wire
- 30 cm - 18 gauge aluminum wire
- Ruler
- Clothespin
- Parchment paper
- 30 cm - 12 gauge aluminum wire

Instructions

1. Read through the instructions and then write your hypothesis below. Consider whether a thin wire will conduct heat more quickly or slowly than a thick wire.
2. Prepare your workspace by placing a piece of parchment paper or other covering on the table to catch any dripping wax.
3. Note the diameter (thickness) of each of the wires listed in the data table below.

4. Secure the thinnest wire by clipping a clothespin to one end of one of the wires. Place the wire with the attached clothespin on the parchment paper.
5. Measure 7 cm from the end of the wire and mark this using a pencil on the parchment paper.
6. Carefully light the candle using a lighter or matches. Hold the lighted candle above the 7 cm mark on the wire and tilt it so some of the melted wax drips onto the middle of the wire. Be careful not to put the candle too close to the parchment paper so you don't start a fire!
7. Wait a couple minutes for the wire and dripped wax to cool and harden completely. The dripped wax will harden and form a small ball. Draw a circle around the wax to indicate how much wax to use for each of the trials.
8. Get ready to start your timer. Using the clothespin to hold one end of the wire, place the other end of the wire in the candle's flame and start the stopwatch.
9. When the ball of wax melts enough for the wax to fall off the wire, stop the stopwatch, remove the wire from the flame and place it back on the parchment paper. Be sure to always use the clothespin to hold the wire to avoid burning yourself.
10. Record the time it took to melt the wax in seconds in the data table.
11. Repeat this process with the other two wires.

Hypothesis:

____

____

Data Table

	Wire diameter	Time to melt wax
Wire 1	1.0 mm	
Wire 2	2.0 mm	
Wire 3	3.0 mm	

Questions

1. Was your hypothesis correct? Why or why not?

2. How does your understanding of conduction explain the results you observed in the experiment?

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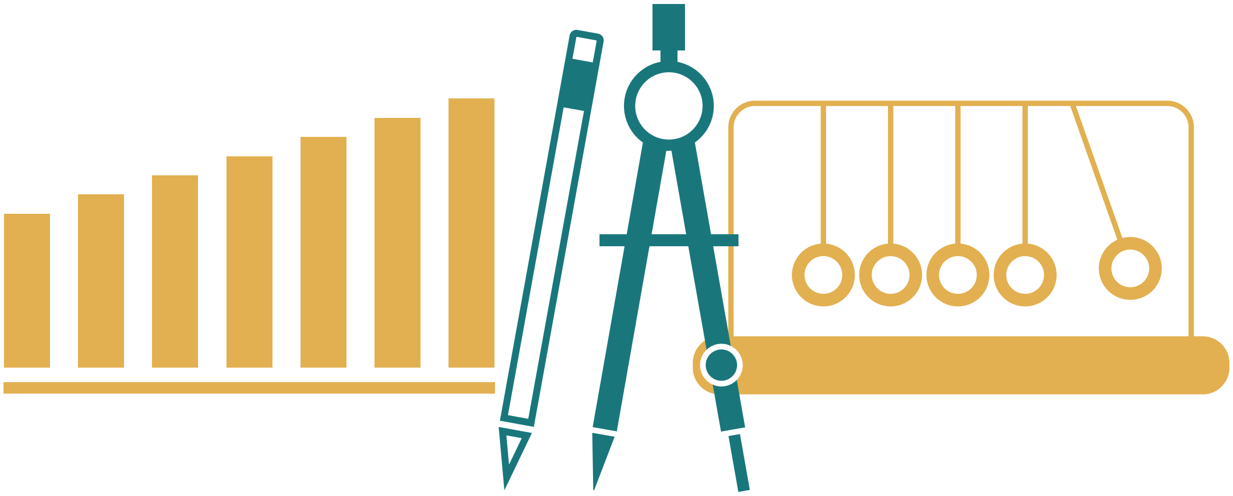

LESSON 26

SIMPLE MACHINES CHALLENGE

Rescuing the Circus Elephant

In this activity, you will use your knowledge of simple machines to engineer a solution for a unique challenge: an elephant has fallen out of a circus railcar! How can we get the elephant back into the rail car using simple machines? Get ready to put your knowledge to work and think creatively!

Supplies

- Pencil with eraser
- Colored pencils or markers
- Ruler
- White paper

The Scenario

The circus was on its way to your town when it derailed! The rail car carrying the elephant tipped and the elephant tumbled over! While local rail workers were able to get the train back on the track, the circus still had a problem: how could they get the elephant back into the rail car? Can you help the circus by designing a device to lift the elephant back into its car? The challenge is that the elephant must be lifted 6 feet into the railcar. Use your knowledge of simple machines to build a device to lift the elephant 6 feet into the rail car. Get ready to put your engineering skills to the test!

Instructions

1. Make a list of all of the simple machines.
2. Brainstorm ideas for an elephant moving device, writing down a couple of different ideas.
3. Remember the following requirements for your design:
    - Limited money for materials
    - Must be fast to get the elephant back in time for the circus
    - Safe for the elephant
    - Use at least two simple machines (no electronic buttons!)
4. Evaluate your ideas and pick the most promising one.
5. Make a drawing of your most promising design.
6. Clearly label all of the parts of your drawing, including the simple machines.
7. Write steps explaining how the machine works.
8. Present your design. Scientists need to be able to communicate their ideas. Present your design and drawing to your family for one minute explaining how your device uses simple machines to solve a problem.

Elephant Moving Device

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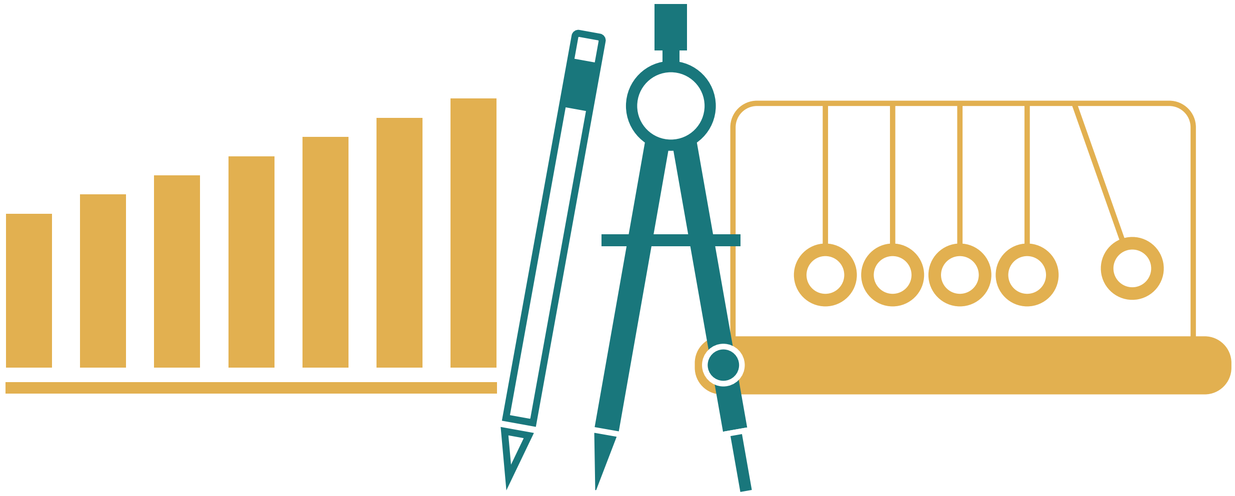


LESSON 28

HANDS-ON WAVE DYNAMICS WITH A SLINKY

Explore the dynamics of waves through our interactive Slinky experiment! With simple manipulations of a simple Slinky, you'll be able to explore key wave properties such as amplitude, wavelength, and frequency in this lab.

Supplies

- Masking tape
- Slinky
- Meterstick
- Stopwatch
- 2 helpers (or a helper and a stationary object)

Instructions

1. Mark one of the loops of a Slinky by folding a small piece of masking tape over one of the loops in the middle.
2. Prepare your surface by placing a line of masking tape about 2 m long on a smooth surface, like a floor or large table.
3. Set up the Slinky. Stretch the Slinky along the tape line between two people or attach one end of the Slinky to a stationary object and hold the other end. This will be the resting position of the wave.

4. Create the wave by having one person hold their end of the Slinky still while the second person gently moves the Slinky from side to side. What type of wave is this? ____________________

5. Observe the particle movement. The masking tape mark represents a particle of the Slinky. Determine what direction the particles of the wave move compared to the direction of the wave—parallel or perpendicular? ____

6. Measure the amplitude of the wave. Use a meterstick to measure how far the Slinky moves from its resting position. Record this distance in centimeters as amplitude on the data table for wave 1.

7. Measure the wavelength of the wave. Continue creating waves with the same amplitude. Measure the distance from the top of one wave to the top of the next wave using a meterstick. If you have a camera, you can place the ruler or meterstick under the wave and take a photo and measure the wavelength from the photo. Record the wavelength on the data table in centimeters for Wave 1.

8. Calculate the frequency of the waves. Continue creating waves with the same amplitude and wavelength. Use a stopwatch to count how many waves are made in 10 seconds. Divide this number by 10 to find the frequency in waves per second. Record this frequency for Wave 1 on the data table.

9. Increase the speed of your hand moving back and forth and height of the waves. Repeat steps 6-8 with the new wave that is created. Record the amplitude, wavelength, and frequency of the wave on the data table for Wave 2.

Data Table

	Amplitude	Wavelength	Frequency
Wave 1			
Wave 2			

Questions

1. Compare the energy of Waves 1 and 2. Which had more energy? Explain how you determined this.

 ____

 ____

2. Is it possible to create a wave with a high frequency but low amplitude? If so, how would you achieve this? If not, why is it not possible?

 ____

 ____

 ____

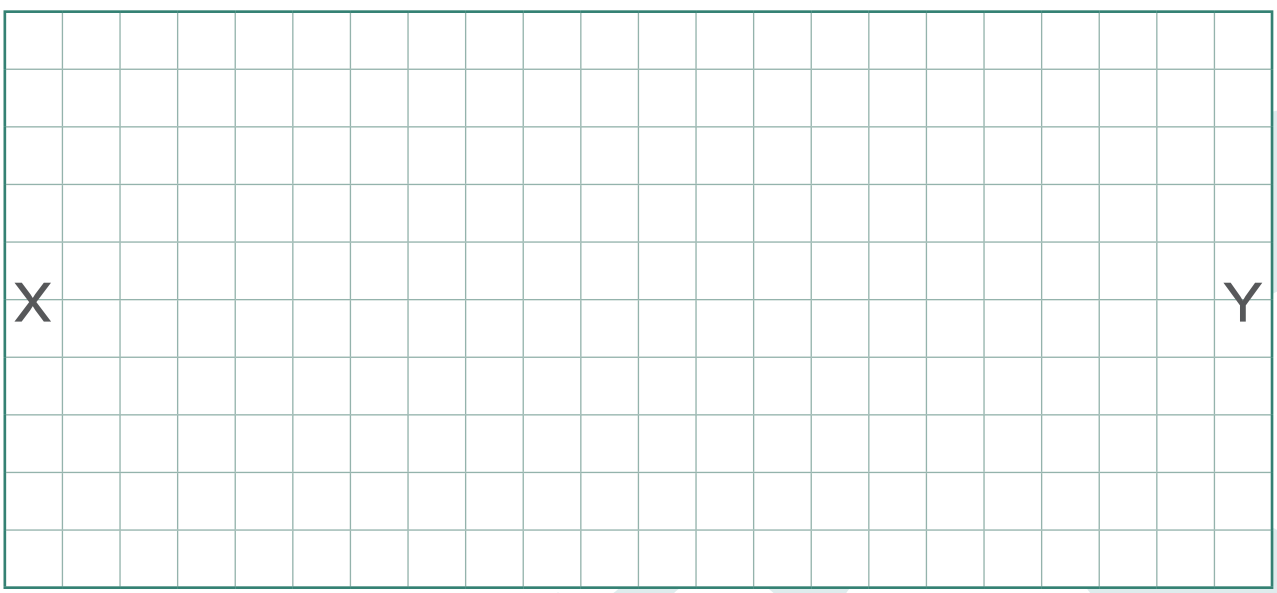
3. Can you produce a wave with a high amplitude and low frequency? If yes, describe how you would do this. If not, explain why it cannot be done.

 ____

 ____

 ____

4. Graph a wave with a wavelength of 6 and an amplitude of 1.



5. Graph a wave with a wavelength of four and an amplitude of five.

X Y

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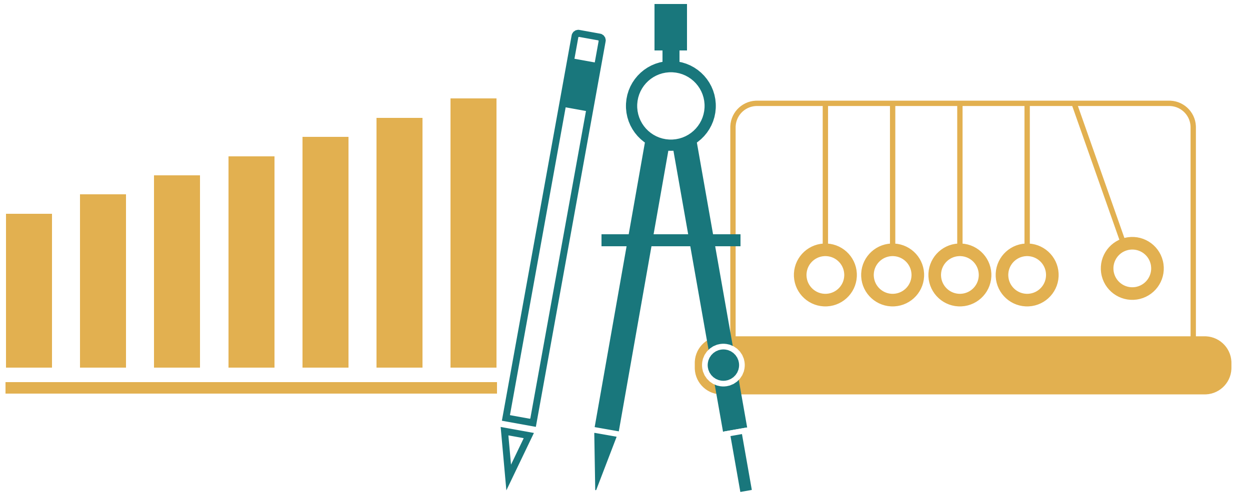

LESSON 29

FREQUENCIES OF SOUND

We know that sound waves are formed by vibrating objects and the frequencies of those sound waves determine the pitch of the sound. Different musical instruments manipulate a variety of different factors to control the pitch of the sounds they produce. Today, we'll explore some of those factors to see how they affect the pitch.

Supplies

- Plastic or metal ruler
- Thin rubber band
- Thick rubber band
- Soda bottle

Instructions

Playing the Ruler

1. Place a plastic or metal ruler off the edge of a table so that 6 in hangs off the edge.
2. Pluck the ruler and observe the note that is created.
3. Move the ruler so that 3 in are hanging off the edge of the table and pluck it again. Is the note higher or lower than the note made at 6 in? ______________________________
4. Move the ruler so that 9 in are hanging off the edge of the table and pluck it again. Is the note higher or lower than the note made at 6 in? ______________________________

Playing the Rubber Band

5. Stretch a thin rubber band lightly between your finger and your thumb. Pluck it with your other hand and notice the note it makes.
6. Stretch the rubber band tighter by moving your finger and thumb farther apart, then pluck it again. Is the note higher or lower? ______________________________
7. Stretch the rubber band even tighter and pluck it again. Is the note higher or lower? __________
8. Stretch a thick rubber band lightly between your fighter and your thumb. Is the note it makes higher or lower than the thin rubber band? ______________________________
9. Stretch the rubber band tighter and pluck it again. Is the note higher or lower? ____________

Playing the Bottle

10. Blow across the mouth of an empty soda bottle so that it makes a sound. Observe the note it creates.
11. Fill the bottle halfway with water and blow across the mouth of the bottle again. Is the note higher or lower? ________________
12. Fill the bottle ¾ of the way with water and blow across the mouth of the bottle again. Is the note higher or lower? ________________

Questions

1. What type of musical instrument might the ruler represent? What factor did you change to influence the frequency/pitch?

   ____

2. What type of musical instrument might the rubber bands represent? What factor did you change to influence the frequency/pitch?

   ____

3. What type of musical instrument might the bottle represent? What factor did you change to influence the frequency/pitch?

   ____

   ____

4. Your friend is tuning their guitar and asks you how they can make the pitch of their string higher. What would you tell them?

____

____

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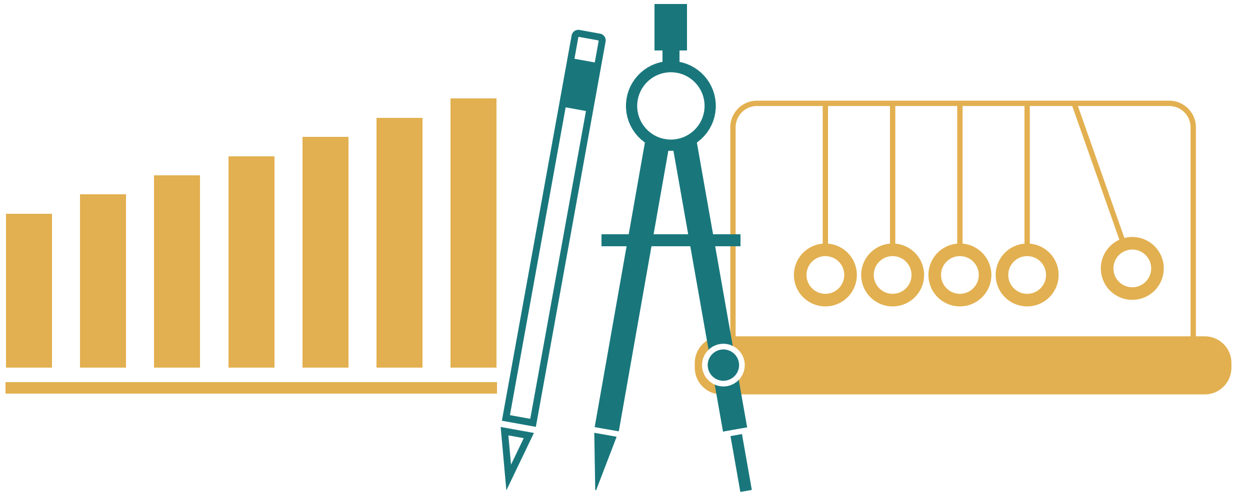

LESSON 30

LIGHT & COLOR DYNAMICS

Explore the magic of color mixing with this hands-on lab activity! Illuminate how overlapping red, blue, and green lights blend to form a spectrum of colors on a white surface, and see how varying light intensity changes the results. Get ready to see colors in a whole new light!

Supplies

- 3 identical flashlights
- 3 rubber bands
- White wall or white poster board
- Red, blue, and green cellophane
- Ruler or meterstick

Instructions

1. Before beginning the lab, read through the instructions and write a hypothesis for what colors you think you'll see for each of the colored light combinations:
    - Red and blue
    - Red and green
    - Blue and green
    - Red, blue, and green
2. Cut a square of red, blue, and green cellophane. Attach one colored piece of cellophane to each flashlight using a rubber band, creating one red, one blue, and one green light.

3. Go into a darkened room to test each light. Project each light onto a white wall, or on a white poster board affixed to a wall and observe the individual red, blue, and green colors.
4. Using a ruler or meterstick, position each flashlight 15 cm from the white surface.
5. Turn on only the red and blue lights and aim the lights at the same location on the wall. Record the color you observe in the overlap on the data table.
6. Turn on only the red and green lights and aim the lights at the same location on the wall. Record the color you observe in the overlap on the data table.
7. Turn on only the blue and green lights and aim the lights at the same location on the wall. Record the color you observe in the overlap on the data table.
8. Turn on all three lights and aim the lights at the same location on the wall. Record the color you observe in the overlap on the data table.
9. Repeat steps 4-7, except dim one of the flashlights by moving it 30 cm from the white surface and leaving the other 15 cm from the white surface. Write down any differences you notice in the overlap on the data table.

Hypothesis:

____

____

____

____

Data Table

	Red & blue	Red & green	Blue & green	Red, green, & blue
Both lights 15 cm from wall				
One light 15 cm & one 30 cm from wall				

Questions

1. Did the observed results match your hypothesis?

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2. How did varying the intensity of the lights (by changing the distance) affect the observed colors?

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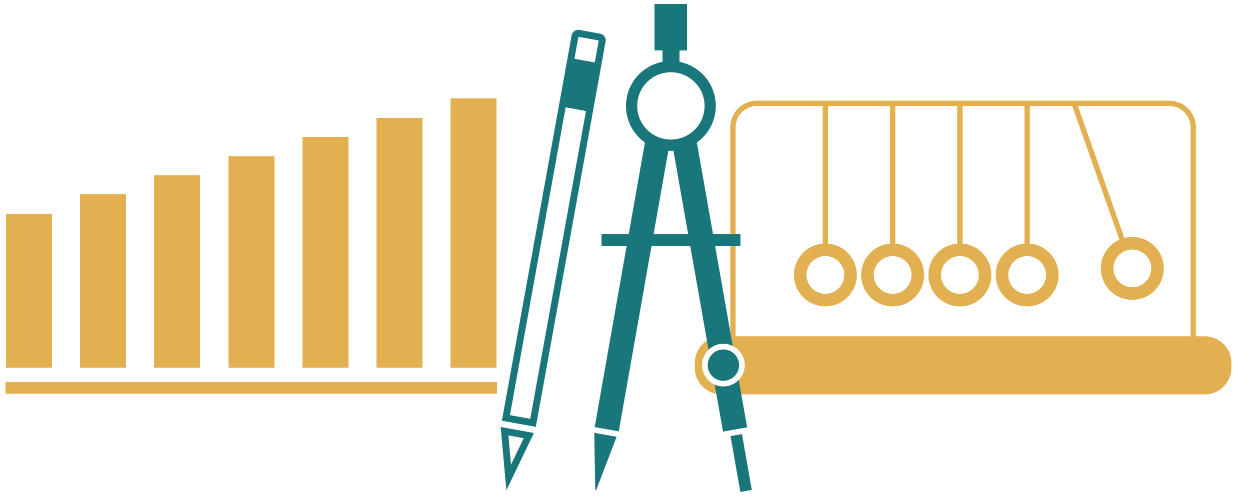

LESSON 31

BENDING LIGHT: REFLECTION & REFRACTION DIAGRAMS

This lab explores the behavior of light through reflection and refraction. Using a laser pointer, you will measure and diagram the angles of incidence, reflection, and refraction as the light interacts with a mirror and a refraction block. This hands-on experience will deepen your understanding of how light travels and bends, revealing the principles of optics in action!

Supplies

- White paper
- Glass plane mirror
- Protractor
- Ruler
- Green laser pointer
- Refraction block
- Pencil

WARNING: The laser pointer is a Class IIIa laser beam. Direct viewing of the laser beam could be hazardous to the eyes. Do not view the laser beam directly. Do not point a laser beam into another person's eyes.

Instructions

Part 1: Reflection Diagrams

1. On a white sheet of paper, begin by drawing a straight line using a ruler to indicate where the mirror will be standing during this lab.
2. Ask a friend or family member to assist you by holding the mirror straight up and down in the place indicated by the line.
3. Turn on your laser pointer and lay it on the table directed towards the mirror, hitting the mirror at any angle (except 90º to the mirror).
4. Plot the light ray marking points to indicate the path of the light ray. Plotting the following points:
    a. Where the ray originates from a laser pointer.
    b Where the incident ray enters the mirror.
    c. Where the reflected ray exits the mirror.
    d. A point several inches down on the reflected ray.
5. Remove the mirror and draw the path of the incident and reflected rays using a ruler to connect the points.
    a. Draw a line connecting the point where the ray originated from the laser pointer to where it met the mirror. Label this line the incident ray.
    b. Draw a line connecting the point where the reflected ray left the mirror to the point you marked further down on the reflected ray. Label this line the reflected ray.
    c. Draw arrows on your rays to show the direction the light was traveling.
6. Draw the normal line.
    a. Place the protractor right in the center of where the incident and reflected ray would meet.
    b. Place a dot at the bottom of the protractor where the two rays would meet.
    c. Place a dot at the top of the protractor at the 90° mark.
    d. Draw a dotted line connecting these two dots.
    e. Label this the normal line.

7. Measure and label your angles.
    a. Measure the angle of incidence using your protractor. Record this in Data Table 1.
    b. Label the angle of incidence.
    c. Measure the angle of reflection using your protractor. Record this in Data Table 1.
    d. Label the angle of reflection.
8. Repeat steps 1-7, for another trial shining the laser pointer at the mirror from a different angle (except 90º to the mirror).

Part 2: Refraction Diagrams

1. Begin by placing the refraction block in the center of a piece of white paper and tracing the block.
2. Draw the normal line.
    a. Mark the center point halfway along the top edge of the block with a pencil.
    b. Center a protractor on the pencil mark you just made.
    c. At the 90° point, place another pencil mark at the top of the protractor.
    d. Draw a dotted line connecting the mark on the block outline to the mark above the protractor. Extend this line halfway into the outline of the block.
    e. Label this the normal line.
3. Turn on your laser pointer and lay it on the table.
4. Shine the laser at any angle (except 90º) toward the refraction block, ensuring the ray meets the refraction block exactly at the normal line.
5. Plot the light rays, marking points to indicate their paths.
    a. Plot a point on the paper where the ray originates from the laser pointer.
    b. Plot a point on the paper showing where the light ray emerges after passing through the refraction block.
6. Draw the path of the ray using a ruler to connect the points.
    a. Draw a line connecting the point where the ray originated from the laser pointer to where it met the block at the normal line.

b. Label this line the incident ray.

c. Draw a line connecting where the light ray met the block at the normal line to where it emerged after passing through the refraction block.

d. Label this line the refracted ray.

e. Draw arrows on your rays to show the direction the light was traveling.

7. Measure and label your angles.

a. Measure the angle of incidence using a protractor. Record this in Data Table 2.

b. Label the angle of incidence on your diagram.

c. Measure the angle of refraction using a protractor. Record this in Data Table 2.

d. Label the angle of refraction on your diagram.

8. Repeat steps 1-7, for another trial shining the laser pointer at the block from a different angle.

Data Table 1: Reflected Rays

	Angle of incidence	Angle of reflection
Trial 1		
Trial 2		

Data Table 2: Refracted Rays

	Angle of incidence	Angle of reflection
Trial 1		
Trial 2		

Questions

1. What is the law of reflection? How did your results support this law?

2. How did the angle of incidence affect the angle of refraction in your experiments?

3. What do you think would happen to the angle of refraction if you changed the material of the refraction block to one with a higher density?

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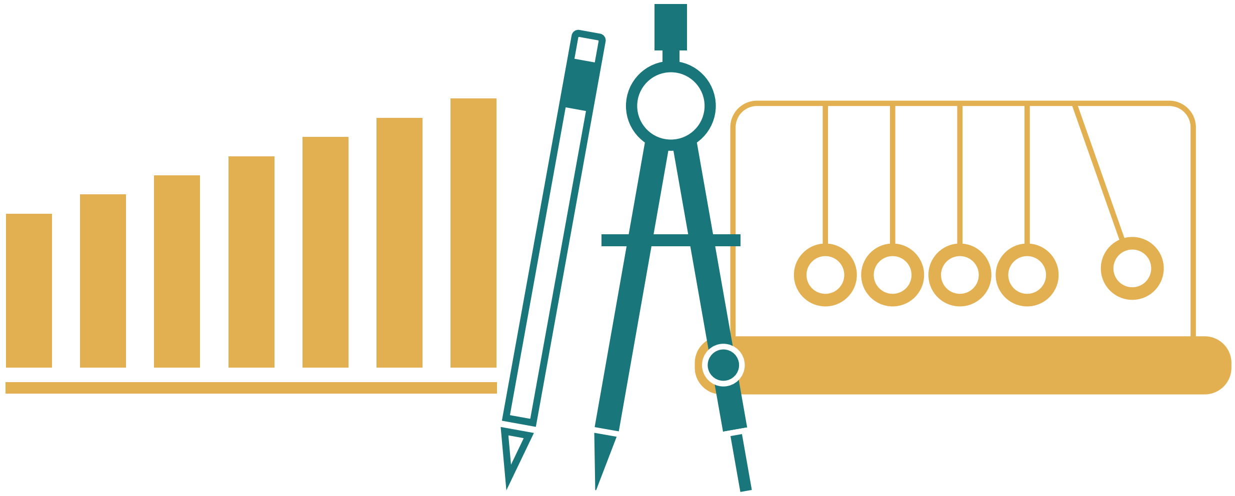

LESSON 32

CONDUCTIVITY IN ACTION

In this lab, you'll investigate the concept of electrical conductivity. Using a simple conductivity tester, you'll learn why some substances are excellent conductors, while others are not. By the end of the lab, you'll be able to categorize materials based on their ability to conduct electricity and gain insight into the properties that make certain substances better conductors than others.

Supplies

- Wooden block
- 3 wires with alligator clips
- Mini light bulb holder
- 2 metal screw hooks
- 6 V battery
- E10 Mini light bulb 3.8 V
- 5 or more of the following:
  - Glass stirring rod
  - Wooden skewer
  - Plastic spoon
  - Metal nail
  - Copper wire
  - Cardboard strip
  - Aluminum foil
  - Piece of chalk

Instructions

1. Before beginning this lab, read the instructions and write a hypothesis about whether each of the materials you gathered will be a good conductor. Record your hypothesis in the data table.
2. Set up the conductivity tester.
    a. Screw two metal screw hooks into one side of the block, spacing them about 2-3 inches apart. You may need to get help to drill small holes in the wood block in order to insert the screw hooks.
    b. Connect one end of a wire with an alligator clip to one of the metal screw hooks. Connect the other end of the wire with an alligator clip to one of the battery terminals.
    c. Connect one end of a second wire to the other battery terminal. Connect the other end of the wire to the screw on the base of the light bulb holder.
    d. Connect one end of the third wire to the screw on the base of the holder of the lightbulb and the other end of the wire to the second metal hook.
    e. Screw a light bulb into the light bulb holder.
3. One at a time, test the conductivity of each material by laying it across the metal hooks of the conductivity tester. Ensure that the material touches both metal hooks. If the bulb lights up, the material is a conductor. If not, it is an insulator. (Observe the brightness of the light. The brighter the light, the better the conductor.)

Data Table

Material	**Hypothesis** Good conductor? Yes or No	**Test** Conductor? Yes or No

Questions

1. Were your hypotheses correct? Why or why not?

____

____

____

2. What are some other materials in your house you could test using this conductivity tester? Do you think they would conduct electricity? Why or why not?

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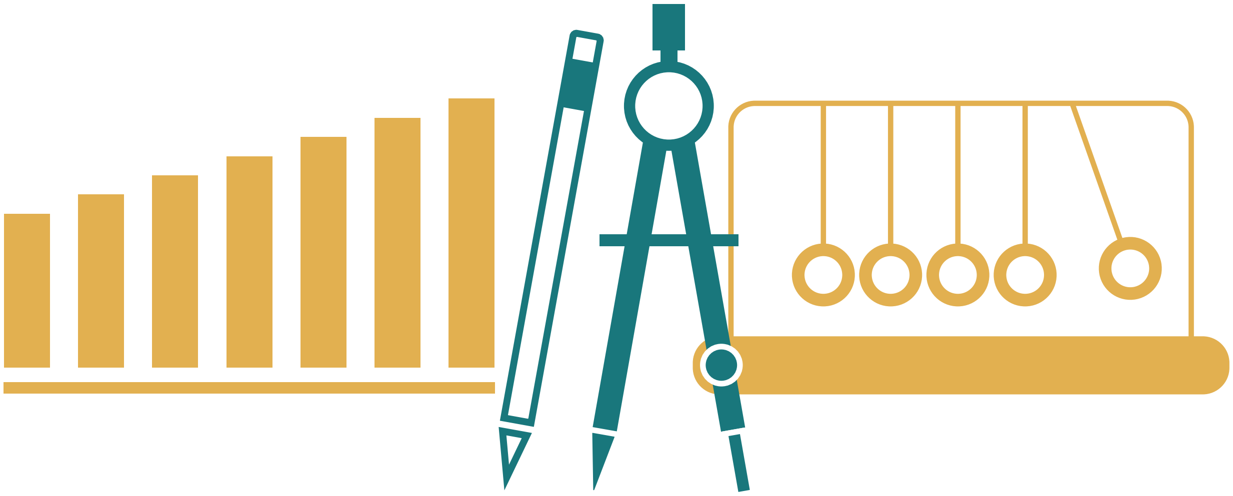

LESSON 33

CIRCUIT DISCOVERY: BUILDING & UNDERSTANDING CONNECTIONS

Light up your understanding of circuits in this hands-on activity exploring circuits. In this lab, you'll put your knowledge into practice by building your own series and parallel circuits. Plus, you'll create circuit diagrams to illustrate your designs.

Supplies

- 5 wires with alligator clips
- 3 mini light bulb holders
- 1 switch
- 6 V battery
- 3 E10 mini light bulb 3.8 V

Instructions

Circuit With One Light Bulb

1. Build a simple circuit by connecting a battery, one lightbulb, and a switch using the wires with alligator clips. Ensure that all parts are connected in a single pathway.
2. Test the circuit. Open and close the switch to observe what happens.
3. In the appropriate box below, draw a diagram of the circuit you just built.

Series Circuit With Two Light Bulbs

1. Create a series circuit by adding another light bulb to the existing pathway. Observe the changes in the circuit's behavior.
2. In the appropriate box below, draw a diagram of the circuit you just built.

Series Circuit With Three Light Bulbs

1. Add one more light bulb to the series circuit you just built. Observe what happens.
2. In the appropriate box below, draw a diagram of the circuit you just built.

Parallel Circuit With Two Light Bulbs With Switch Controlling both Light Bulbs

1. Go back to your original circuit with the battery, one light bulb, and a switch.
2. Build on this and create a parallel circuit by clipping new wires with alligator clips to the ones already connected to the light bulb. Connect the free ends of those wires to another light bulb. Open and close the switch to see what happens.
3. In the appropriate box below, draw a diagram of the parallel circuit you just built.

Parallel Circuit With Two Light Bulbs and a Switch Controlling One Light Bulb

1. Rearrange the parallel circuit so only one of the lights turns off when you open and close the switch.
2. In the appropriate box below, draw a diagram of the circuit you just built.

Circuit Diagram With One Light Bulb

Series Circuit Diagram With Two Light Bulbs

Series Circuit Diagram With Three Light Bulbs

Parallel Circuit Diagram With Two Light Bulbs With Switch Controlling both Light Bulbs

Parallel Circuit Diagram With Two Light Bulbs and a Switch Controlling One Light Bulb

Questions

1. What happened when you added more light bulbs to the series circuit? Why do you think that is?

____

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____

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2. What happened when you added more light bulbs to the parallel circuit? Why do you think that is?

____

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____

____

3. Can you explain how the switch controls the flow of electricity in your circuit?

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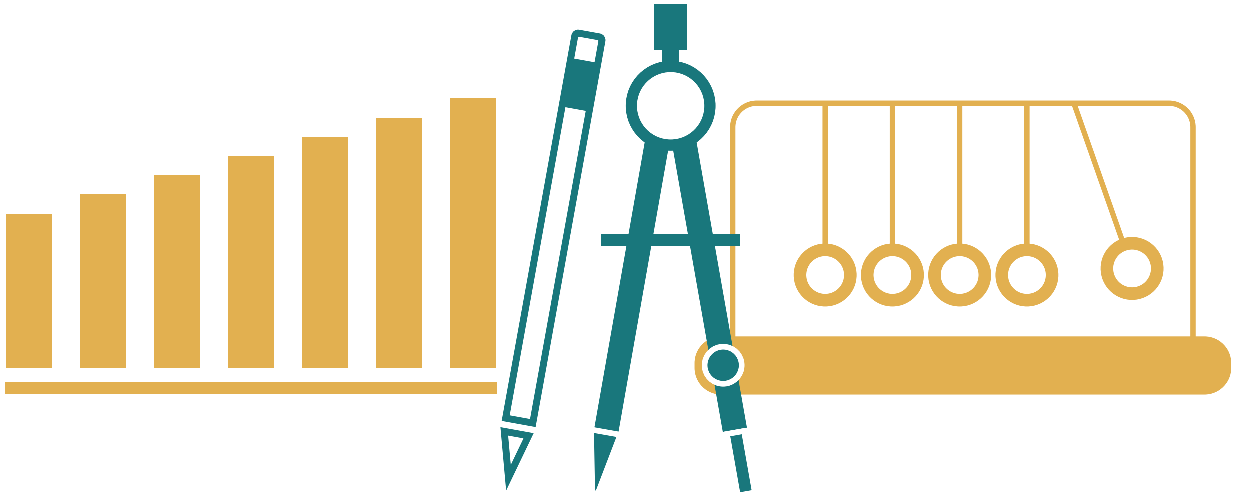

LESSON 34

THE SCIENCE OF COMPASS-MAKING

In today's lab, you'll get hands-on experience creating your very own compass. Using a simple sewing needle, a cork, and a few everyday items, you'll discover how magnets interact with the Earth's magnetic field.

Supplies

- Bar magnet
- Sewing needle or small pin
- Bowl of water
- Paper clips
- Small piece of cork

Instructions

1. Start by testing the strength of the bar magnet. Attach paper clips to the magnet one by one to form a chain. Count how many paper clips you can hang before the last one falls off.
2. Remove the top paper clip from the magnet and observe what happens to the remaining paper clips.
3. Magnetize the needle by rubbing the bar magnet along the needle in one direction about 30-40 times. Do not rub it back and forth. This aligns the needle's particles and turns it into a magnet.

4. Check if the needle is magnetized by bringing its point close to a paper clip. If it doesn't attract the paper clip, repeat the previous step until the needle can pick up the paper clip.

5. Prepare a floating base.

    a. Fill the bowl or tray with water.

    b. Take the cork piece and gently push the needle through the center. Make sure it's balanced.

    c. Carefully place the cork on the surface of the water.

6. Carefully lay the needle and cork on the water and observe what happens.

7. Carefully pick up the bowl and turn it slowly to face different directions. Observe what happens to the needle.

Questions

1. How many paper clips did your magnetic chain contain? According to the lesson, how does the strength of a magnet affect how many paper clips it can pick up?

____

____

____

____

____

2. What happened when you removed the top paper clip from the magnet?

____

____

3. What happened when you put the needle on top of the cork?

____

____

4. What happened when you turned in different directions?

____

____

5. Why does the needle point in a specific direction when you turn the bowl?

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