PHYSICAL SCIENCE EXPLORED

LAB & ACTIVITY GUIDE

Parent Answer Key

Lesson 1: Freezing Liquids & Exploring the Scientific Method

Problem: Which substance will melt the fastest: water, milk, or orange juice?

Hypothesis: Example*:* I think the water will melt the fastest because it doesn't have anything else in it to slow it down.

Data Table

	Type of Liquid	Trial #1 Time	Trial #2 Time
Substance #1	Water	10.03 minutes	10.01 minutes
Substance #2	Milk	8.87 minutes	8.89 minutes
Substance #3	Orange Juice	9.95 minutes	9.92 minutes

** Data is meant as an example and will vary based on substances used, size of ice cubes, temperature of the room, etc.*

Questions

1. What was the independent variable in this experiment?
   The type of substance (water, milk, orange juice).

2. What was the dependent variable?
   The time it took to melt.

3. Which of the ice cubes melted the fastest?
   Answers will vary

4. Was your hypothesis correct? Why or why not?
   Answers will vary.

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

Example: Milk has things other than water in it, so the other parts of the milk may have made it melt faster.

Lesson 2: Scientific Measurements

Data Table

Textbook length	24.70 cm*
Textbook width	17.00 cm*
Textbook height	2.50 cm*
Water volume	12.58 mL**
Jumping jacks time	7.24 s**

*Textbook answers based on Novare Physical Science, 1st edition

***Answers will vary. Sample data included to help with conclusion questions.*

Questions

1. Convert the length, width, and height of your textbook into meters.
    a. Length (24.70 cm/1) x (1 m/100 cm) = 0.247 m
    b. Width (17.00 cm/1) x (1 m/100 cm) = 0.17 m
    c. Height (2.50 cm/1) x (1 m/100 cm) = 0.025 m

2. Calculate the volume of your textbook in meters cubed by multiplying the length, width, and height from your answers in number 1.
   0.247= m x 0.17 m x 0.025 m = 0.00104975 m^3

3. How many liters of water did you have in your graduated cylinder (convert milliliters to liters)?
   (12.58 mL/1) x (1 L/1000 mL) = 0.001258 L

4. How many milliseconds did it take for you to do 10 jumping jacks (convert seconds to milliseconds)?
   (7.24 s/1) x (1000 ms/1 s) = 7,240 ms

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.)?
   Answers will vary but could include a meter/yardstick, measuring tape, measuring wheel, odometer, etc.

Lesson 3: Bullseye! Activities to Explore Accuracy & Precision

Activity 1 Questions

1. Were your Xs accurate? Why or why not?
   Yes, because they were close to the bullseye.
   OR
   No, because they were not close to the bullseye.

2. Were your Xs precise? Why or why not?
   Yes, because they were all really close together.
   OR
   No, because they were not close to each other.

Activity 2 Questions

2. Were your throws accurate? Why or why not?
   Yes, because they made it in (or close to) the trash can
   OR
   No, because they did not make it in (or close to) the trash can

3. Were your throws precise? Why or why not?
   Yes, because they all landed in about the same spot
   OR
   No, because they did not land close to each other

Activity 3 Questions

2. Were your shots accurate? Why or why not?
   Yes, because they hit (or got close to) the cup
   OR
   No, because they were not close to the cup

3. Were your shots precise? Why or why not?
   Yes, because they all ended up near each other
   OR
   No, because they did not end up close to each other

3. Why do you think it’s important for measurements in science to be accurate and precise?
   Answers will vary but could include that scientists want to make sure their results are right and can be repeated both by themselves and other scientists in order to be valid.

Lesson 4: Physical vs. Chemical Changes

Data Table

	Observations	Type of change and why
Mixing salt and water	Just looked like water after the salt dissolved	Physical - salt and water will still be there, nothing new was formed
Evaporating water	White layer on the bottom of the pot when the water was gone	Physical - change of state
Ice cube	Melted - went from solid to liquid	Physical - it was still water, just in different forms
Baking soda and vinegar	Produced bubbles, made a fizzing noise, balloon inflated	Chemical - it formed a gas

Discussion Questions

1. Was it difficult to tell if the changes were physical or chemical? Why or why not?
   Answers will vary, but the baking soda and vinegar and the ice cube should have been fairly easy, while the other two may have been more challenging for some students.

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

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

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

Lesson 5: Calculating & Comparing Density

Hypothesis:

Example: I think in order from least dense to most dense, the cylinders will be aluminum, steel, brass, copper because aluminum is the lightest and copper is the heaviest, and I think dense objects would be heavier.

Data Table

Metal	Mass of metal	Initial volume of water	Final volume of water + metal	Volume of metal (Final volume - initial volume)	Density of metal
Aluminum	17.39 g	12.00 mL	16.44 mL	6.44 mL	2.70 g/mL
Brass	55.38 g	11.50 mL	15.94 mL	6.44 mL	8.60 g/mL
Steel	50.68 g	15.00 mL	21.44 mL	6.44 mL	7.87 g/mL
Copper	57.70 g	13.35 mL	19.79 mL	6.44 mL	8.96 g/mL

Students' calculation of the density of the metals should be very similar to what is recorded if they completed the lab correctly. There could be slight variations due to imprecise measurements. The mass of the metal, initial volume of water, and final volume of water are hypothetical and will vary from what is listed.

Discussion 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

       D = ? m = 17.29 g V = 6.44 mL

       D = m/V D = 17.29 g/6.44 mL D = 2.70 g/mL

b. Brass

D = ?	m = 55.38 g	V = 6.44 mL
D = m/V	D = 55.38 g/6.44 mL	D = 8.60 g/mL

c. Steel

D = ?	m = 50.68 g	V = 6.44 mL
D = m/V	D = 50.68 g/6.44 mL	D = 7.87 g/mL

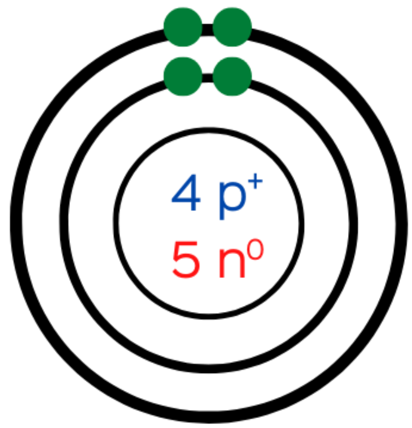
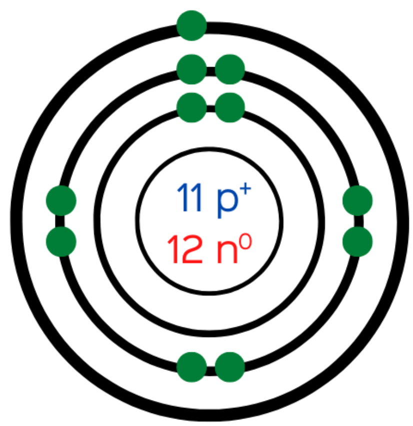
d. Copper

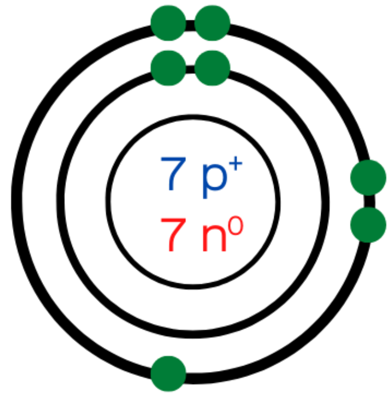
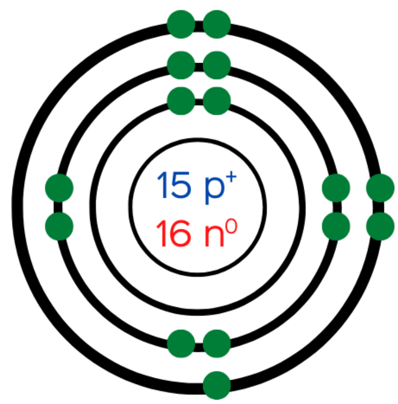
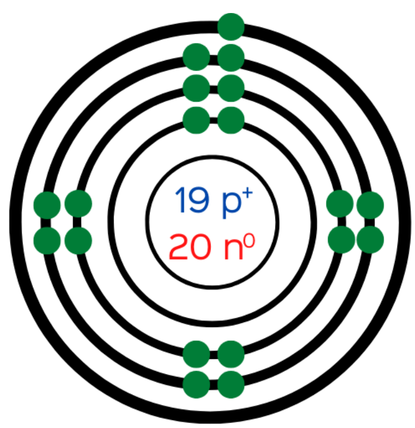
D = ?	m = 57.70 g	V = 6.44 mL
D = m/V	D = 57.70 g/6.44 mL	D = 8.96 g/mL

2. Based on your data, list the metals from least dense to most dense. Was your hypothesis correct? Why or why not?
   Aluminum, steel, brass, copper. Whether or not your student's hypothesis was correct will vary.

3. What do you think would happen to the densities if we doubled the amount of metal in the cylinders? Why?
   The densities would stay the same. Even though the cylinders would be bigger in volume, their mass would also be bigger. Since density is an intrinsic property, the density of a substance stays the same no matter how much of it there is.

Lesson 6 Lab: Building Bohr Models

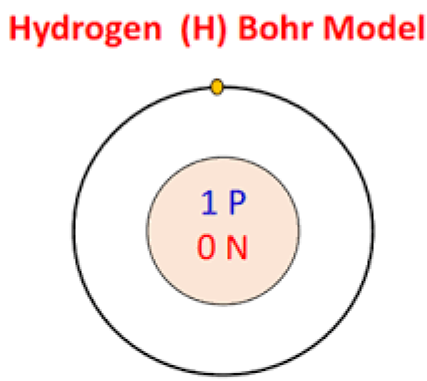
Element info	**Bohr model drawing**
Beryllium p^+ = _____4_____ n^o = _____5_____ e^- = _____4______	
Sodium p^+ = ____11______ n^o = ____12______ e^- = _____11______	

Nitrogen p^+ = ____7______ n^o = ____7______ e^- = ____7______	
Phosphorus p^+ = ____15______ n^o = ____16______ e^- = _____15______	
Potassium p^+ = ____19______ n^o = ____20______ e^- = ____19______	

Lesson 7: Introducing the Periodic Table

Below is just an example of what student answers would look like for the element hydrogen. Your student may choose whatever element they would like and answers will vary.

Element name	Hydrogen
Discovered by (scientist name)	Henry Cavendish (he is credited, but several scientists produced it before him)
Date discovered	1766
Where it is found in nature or what we use it for	In the sun and stars, small amounts are in air, bonded with oxygen to form water; used to refine oil, treat metals, produce fertilizer, and generate electricity.
Description/ properties (color, state of matter, safety info, etc.)	Colorless, odorless, tasteless, non-toxic gas, extremely flammable/combustible
Fun/ cool fact about element	Hydrogen is the most abundant element on Earth.
Nuclear notation	${}^{1}_{1}H$
Hyphen notation	Hydrogen - 1
Protons	1
Neutrons	0
Electrons	1
Average atomic mass	1.01 amu
Molar mass	1.01 g/mol

Mass number	1
Period number	1
Group number	1
Valence electrons	1
Ion charge	+1
Bohr model	 [1]
Other information (optional)	Could include picture/sketch, how it was discovered, historical/scientific significance, etc.

Lesson 8: Stability and Types of Bonding

Data Table

Compound	Initial observations	Melting point	Dissolves in water?	Dissolves in ethanol?	Conducts electricity?
Calcium Chloride ($CaCl_2$)	White, flaky crystals	3 (N)	Yes	Yes	Yes
Candle Wax ($C_{25}H_{52}$)	Smooth, shiny	1	No	No	No
Sodium Chloride (NaCl)	White crystals	4 (N)	Yes	Yes	Yes
Sugar ($C_{12}H_{22}O_{11}$)	White crystals	2	Yes	No	No

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."
   Group 1 - Calcium chloride, sodium chloride
   Group 2 - Candle wax, sugar

2. List the properties of each group based on your observations.
   Group 1 - difficult to melt, dissolves in water and ethanol, solution conducts electricity
   Group 2 - easy to melt, does not dissolve in water or ethanol, solution does not conduct electricity

3. Write a statement to summarize the properties of ionic compounds and another statement to summarize the properties of covalent compounds.
   Ionic compounds have high melting and boiling points, are usually hard, brittle, crystals, and dissolve in water to form solutions that conduct electricity.

   Covalent compounds are usually gases or liquids (or soft solids) at room temperature, have low melting and boiling points, and either do not dissolve in water or dissolve to form solutions that do not conduct electricity.

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.
   Ionic bonds. For example, salt has the highest melting point, dissolved in water, and it conducts electricity when dissolved.

5. Which group from question one do you think contained ionic bonds and which contained covalent bonds?
   Group 1 contained ionic bonds and Group 2 contained covalent bonds.

6. Did every test support your answer to #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?
   No. For example, sugar dissolved in water but it contains covalent bonds. Maybe something went wrong with the lab, or there are other reasons compounds dissolve in water besides just the types of bonds they have.

Lesson 10: Reading and Writing Chemical Formulas for Ionic Compounds

Questions

1. What is the chemical formula of magnesium sulfate?
   $Mg(SO_4)$

2. How did the Epsom salts you dissolved differ from the crystals you ended up with?
   Answers will vary, but students should indicate that the crystals were long, needle-like, possibly colored whereas the original Epsom salts were small and grainy.

3. Based on what you know about ionic compounds, why do you think these crystals were able to form?
   Answers will vary. Could include rigid structure of bonds, ionic compounds tend to form crystals and have a high melting point.

Lesson 11: Naming Ionic Compounds

Data Table

Cation Symbol	Anion Symbol	Chemical Formula	Compound Name
K^+	Cl^-	KCl	Potassium chloride
K^+	$(PO_4)^{3-}$	K_3PO_4	Potassium phosphate
K^+	F^-	KF	Potassium fluoride
K^+	O^2	K_2O	Potassium oxide
K^+	N^{3-}	K_3N	Potassium nitride
K^+	$(SO_4)^{2-}$	$K_2(SO_4)$	Potassium sulfate
Mg^{2+}	$(PO_4)^{3-}$	$Mg_3(PO_4)_2$	Magnesium phosphate
Mg^{2+}	N^{3-}	Mg_3N_2	Magnesium nitride
Mg^{2+}	Cl^-	$MgCl_2$	Magnesium chloride
Mg^{2+}	F^-	MgF_2	Magnesium fluoride
Mg^{2+}	O^2	MgO	Magnesium oxide
Mg^{2+}	$(SO_4)^{2-}$	$Mg(SO_4)$	Magnesium sulfate
Cu^{2+}	O^{2-}	CuO	Copper (II) oxide
Cu^{2+}	Cl^-	$CuCl_2$	Copper (II) chloride
Cu^{2+}	F^-	CuF_2	Copper (II) fluoride
Cu^{2+}	$(PO_4)^{3-}$	$Cu_3(PO_4)_2$	Copper (II) phosphate
Cu^{2+}	N^{3-}	Cu_3N_2	Copper (II) nitrate

Cu^{2+}	$(SO_4)^{2-}$	$Cu(SO_4)$	Copper (II) sulfate
Fe^{3+}	$(SO_4)^{2-}$	$Fe_2(SO_4)_3$	Iron (III) sulfate
Fe^{3+}	N^{3-}	FeN	Iron (III) nitride
Fe^{3+}	O^{2-}	Fe_2O_3	Iron (III) oxide
Fe^{3+}	Cl^{-}	$FeCl_3$	Iron (III) chloride
Fe^{3+}	F^{-}	FeF_3	Iron (III) fluoride
Fe^{3+}	$(PO_4)^{3-}$	$Fe(PO_4)$	Iron (III) phosphate
Al^{3+}	F^{-}	AlF_3	Aluminum fluoride
Al^{3+}	$(SO_4)^{2-}$	$Al_2(SO_4)_3$	Aluminum sulfate
Al^{3+}	N^{3-}	AlN	Aluminum nitride
Al^{3+}	O^{2-}	Al_2O_3	Aluminum oxide
Al^{3+}	Cl^{-}	$AlCl_3$	Aluminum chloride
Al^{3+}	$(PO_4)^{3-}$	$Al(PO_4)$	Aluminum phosphate
Pb^{4+}	$(SO_4)^{2-}$	$Pb(SO_4)_2$	Lead (IV) sulfate
Pb^{4+}	N^{3-}	Pb_3N_4	Lead (IV) nitride
Pb^{4+}	O^{2-}	PbO_2	Lead (IV) oxide
Pb^{4+}	Cl^{-}	$PbCl_4$	Lead (IV) chloride
Pb^{4+}	F^{-}	PbF_4	Lead (IV) fluoride
Pb^{4+}	$(PO_4)^{3-}$	$Pb_3(PO_4)_4$	Lead (IV) phosphate

Lesson 12: Names and Formulas for Covalent Compounds

Data Table

Name	**Chemical Formula**	**Properties**	**Uses**
Phosphorus Pentachloride	PCl_5	Greenish-yellow crystal (solid), irritating odor, harmful to inhale, very reactive with air and water	Manufacturing other chemicals, pharmaceuticals (like penicillin)
Sulfur Dioxide	SO_2	Colorless, toxic gas, smells like rotten eggs	Making sulfuric acid, paper, and food preservatives
Bromine Pentafluoride	BrF_5	Colorless/pale yellow liquid, very toxic, strong odor	Propelling rockets, manufacturing other chemicals (fluorocarbons)
Dinitrogen Monoxide	N_2O	Colorless, nonflammable gas, sweet scent and taste	Laughing gas (used in medical/dental fields as an anesthetic), used as a propellant in aerosol cans of whipped cream
Tetraphosphorus Decoxide	P_4O_{10}	White crystal, absorbs water easily	Forms phosphoric acid, (a major industrial acid), used as a drying agent

Chlorine Trifluoride	ClF_3	Colorless gas or greenish-yellow liquid, sweet, suffocating odor	Nuclear fuel processing, propelling agent in rockets

Lesson 13: Balancing Chemical Equations

2 $NaCl$	I_2	→	2 NaI	Cl_2
Na_2S	2 HCl	→	H_2S	2 $NaCl$
2 Al	3 Br_2	→	2 $AlBr_3$	
2 Ni_2O_3		→	4 Ni	3 O_2
2 Al	3 ZnO	→	Al_2O_3	3 Zn

Questions:

1. Did a chemical change occur during this experiment? How do you know?
   Yes, because a gas was formed

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.
   Yes, because mass was conserved during the reaction

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.
   No, because the gas that was produced during the reaction was released, so the mass of the system decreased when the bottle was opened.

Lesson 14: Types of Chemical Reactions

Part 1 Questions:

1. Record your observations from the reaction (what you see, hear, and feel):
   When the yeast was added, the mixture foamed and overflowed from the cylinder. Heat was also given off during the reaction, so the graduated cylinder is warm.

2. The chemical equation for this reaction is $H_2O_2 \rightarrow H_2 + O_2$. "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?
   Decomposition

Part 2 Questions:

1. Record your observations from the reaction (what you see, hear, and feel).
   Steel wool turns from gray to reddish brown, and the blue solution gets clearer. The test tube gets warmer.

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

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

Part 3 Questions:

1. Record your observations from the reaction (what you see, hear, and feel):
   The solution becomes blue and cloudy, a solid is formed.

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

Double replacement.

3. Think back to the signs that a chemical change has occurred. How do you know this is a chemical reaction?
   A solid (precipitate) was formed.

Part 4 Data/Questions

1. Record your observations from the reaction (what you see, hear, and feel):
   Rust is formed on the steel wool (turns from gray to brown)

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?
   Synthesis.

Lesson 15: Solutions

Questions:

1. Is magnesium sulfate soluble in water? Why or why not?
   Yes, because it dissolved.

2. Calculate the molarity of the magnesium sulfate solution (3.00 grams of magnesium sulfate = 0.025 moles). HINT: How much water did you use to make the solution?
   M = ? mol = 0.025 mol L = (50 mL/1) x (1 L/1000 mL) = 0.05 L
   M = mol/L M = 0.025 mol/0.05 L M = 0.50 M

3. Is sodium carbonate soluble in water? Why or why not?
   Yes, because it dissolved.

4. Calculate the molarity of the sodium carbonate solution (3.00 grams of sodium carbonate = 0.028 moles). HINT: How much water did you use to make the solution?
   M = ? mol = 0.028 mol L = (50 mL/1) x (1 L/1000 mL) = 0.05 L
   M = mol/L M = 0.028 mol/0.05 L M = 0.56 M

5. Which of the two solutions is stronger or more concentrated? How do you know?
   The sodium carbonate, because it has a higher molarity.

6. Is the product of the reaction between magnesium sulfate and sodium carbonate soluble in water? Why or why not?
   No, because when they mixed, it formed a solid (precipitate). If it was soluble, no solid would have formed.

Lesson 16: Acids & Bases

Data:

Student results will vary depending on the substances they test. If the pH of the substance is less than 7, the last column should say "acid." If it is greater than 7, the last column should say "base." If it's 7, it should say "neutral."

Lesson 17: Nuclear Changes

Data Table

Trial #	Heads-up pennies
0	128
1	64
2	32
3	16
4	8
5	4
6	2
7	0
8	
9	
10	
11	
12	
13	
14	
15	

Amounts and number of trials will vary.

Questions:

1. What did the pennies represent in this lab?
   A sample of a radioactive substance

2. What did one trial represent?
   A half-life

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

4. Was this true for every trial? If not, why do you think that happened?
   Answers will vary. Since there is an element of chance with the pouring out of the pennies, it would probably not be exactly half with each shake.

Lesson 19: Calculating Velocity

Data Table

Person (or Trial #)	Distance	Time
Me	30.25 m	4.62 s
Mom	30.25 m	5.16 s
Dad	30.25 m	4.74 s

*The data and calculations are sample data. Your students' calculations will vary.

Questions

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

   Me:

   v = ? d = 30.25 m t = 4.62 s

   v = d/t

   v = 30.25 m / 4.62 s v = 6.55 m/s

   Mom:

   v = ? d = 30.25 m t = 5.16 s

   v = d/t

   v = 30.25 m / 5.16 s v = 5.86 m/s

   Dad:

   v = ? d = 30.25 m t = 4.74 s

   v = d/t

   v = 30.25 m / 4.74 s v = 6.38 m/s

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

   I was the fastest because I traveled the same distance as Mom and Dad but in less time.

Lesson 20: Exploring Acceleration

Data Table

Trial	Distance	Time
#1 (Top of Ramp)	1.83 m	2.48 s
#2 (High Mark)	1.22 m	2.05 s
#3 (Low Mark)	0.61 m	1.60 s

Questions

1. Calculate the velocity for each trial.

   Trial 1

   v = ? d = 1.83 s t = 2.48 s

   v = d/t

   v = 1.83 m/ 2.48 s v = 0.74 m/s

   Trial 2

   v = ? d = 1.22 m t = 2.05 s

   v = d/t

   v = 1.22 m/ 2.05 s v = 0.60 m/s

   Trial 3

   v = ? d = 0.61 m t = 1.60 s

   v = d/t

   v = 0.61 m/ 1.60 s v = 0.38 m/s

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.

   Trial 1

   a = ? v_i = 0 m/s v_f = 0.74 m/s t = 2.48 s

   a = $\frac{v_f - v_i}{t}$

a = $\frac{.74\ m/s - 0\ m/s}{2.48\ s}$ a = 0.30 m/s^2

Trial 2

a = ? v_i = 0 m/s v_f = 0.60 m/s t = 2.05 s

a = $\frac{v_f - v_i}{t}$

a = $\frac{0.60\ m/s - 0\ m/s}{2.05\ s}$ a = .29 m/s^2

Trial 3

a = ? v_i = 0 m/s v_f = 0.38 m/s t = 1.60 s

a = $\frac{v_f - v_i}{t}$

a = $\frac{0.38\ m/s - 0\ m/s}{1.60\ s}$ a = 0.24 m/s^2

Lesson 21: Exploring Inertia

Data Table

Station #	Hypothesis	Observations	Hypothesis Correct? (Yes or No)
1	I think the penny will fall straight into the cup	The penny fell straight into the cup	Yes
2	I think the penny will fall to the floor because it will drop too fast for me to catch it	I was able to catch the penny when I dropped my elbow	No
3	I think the stack of quarters will fall over	The bottom quarter slid out from the stack, but the rest of the stack dropped where it was and stayed together	No
4	I think the ping-pong ball will be really easy to shake so I can shake it really fast, but the bowling ball will be much slower and harder to shake	The ping pong ball was really easy to shake and the bowling ball was really difficult. The bowling ball went much slower than the ping pong ball	Yes
5	I think all of the dishes will fall on the floor when I pull the tablecloth	The dishes all stayed on the table and I was able to get the tablecloth out from underneath them	No

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.
   Each of the stations demonstrated inertia - all of them had objects resisting a change in motion. The penny didn't travel with the card when it was flicked, it stayed in the same place which allowed it to fall into the cup. The penny on my elbow was

easier to catch than I thought it would be because it started at rest and took awhile to fall. The quarters on top of the stack didn't have a force pushing them away like the bottom one did, so they stayed in the same spot. The ping pong ball had less mass, so it accelerated more easily than the bowling ball. Finally, there was not a lot of friction between the tablecloth and the table, so it was easy to pull away and the dishes had enough inertia to stay where they were and not fall with the tablecloth.

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!
Answers will vary.

Lesson 22: Explorations in Gravity & Air Resistance

Part 1: Two balls of different masses

Hypothesis: Both balls will land at the same time because the pull of gravity is the same on both of them.
Observations: Both balls landed at the same time

Part 2: Ball and a piece of paper

Hypothesis: The paper will take longer to land because it will have more air resistance.
Observations: The baseball fell straight down and the paper floated back and forth before finally hitting the ground.

Part 3: Ball launch vs ball drop

Hypothesis: The tennis ball will land in the same amount of time for both trials because gravity is the only thing affecting the vertical motion of both.

	Height (m)	Time (s)	Velocity
Ball launch	1 m	0.45 s	2.22 m/s
Ball drop	1 m	0.45 s	2.22 m/s

Observations: The ball drop and launch had the same time and velocity because gravity has the same effect when the ball is dropped or launched.

Part 4: Parachute launch

Hypothesis: The parachute will start falling quickly, then will slow down and drop at the same slow speed until it hits the ground.
Observations: The parachute began accelerating quickly when it was released, but the acceleration slowed down and it fell at the same slow speed until it hit the ground.

Questions

1. Were your hypotheses correct? Why or why not?
   Answers will vary depending on whether or not the students' hypotheses were correct. However, they should use their understanding of gravity and air resistance from the lesson to make educated guesses about what will happen.

2. How did you see the effects of gravity in this experiment?
   Since all of the objects were falling, they could see the effects of gravity in each experiment and notice that when air resistance wasn't noticeable, objects all fell at the same rate.

3. How did you see the effects of air resistance in this experiment?
   Answers may vary. With the lighter, wider objects (objects with a larger surface ' area), air resistance slowed the objects down. With the parachute especially since it was dropped from a taller height, we could see how an object can start off moving quickly, and as it accelerates, air resistance increases until it reaches terminal velocity and falls at the same rate until it hits the ground.

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?
   Answers will vary.

Lesson 23: Building a Slingshot

Hypothesis*:* I think the marble will travel farther than the slingshot because the slingshot has a larger mass. The slingshot will move a little though because of the reaction force on the slingshot.

Data Table

Mass of slingshot	37.99 g
Mass of Marble	5.48 g
Distance Marble Traveled	110.5 in

**The data is just an example and may vary greatly (the mass of the marble may even be larger than the mass of the slingshot - not likely, but possible).*

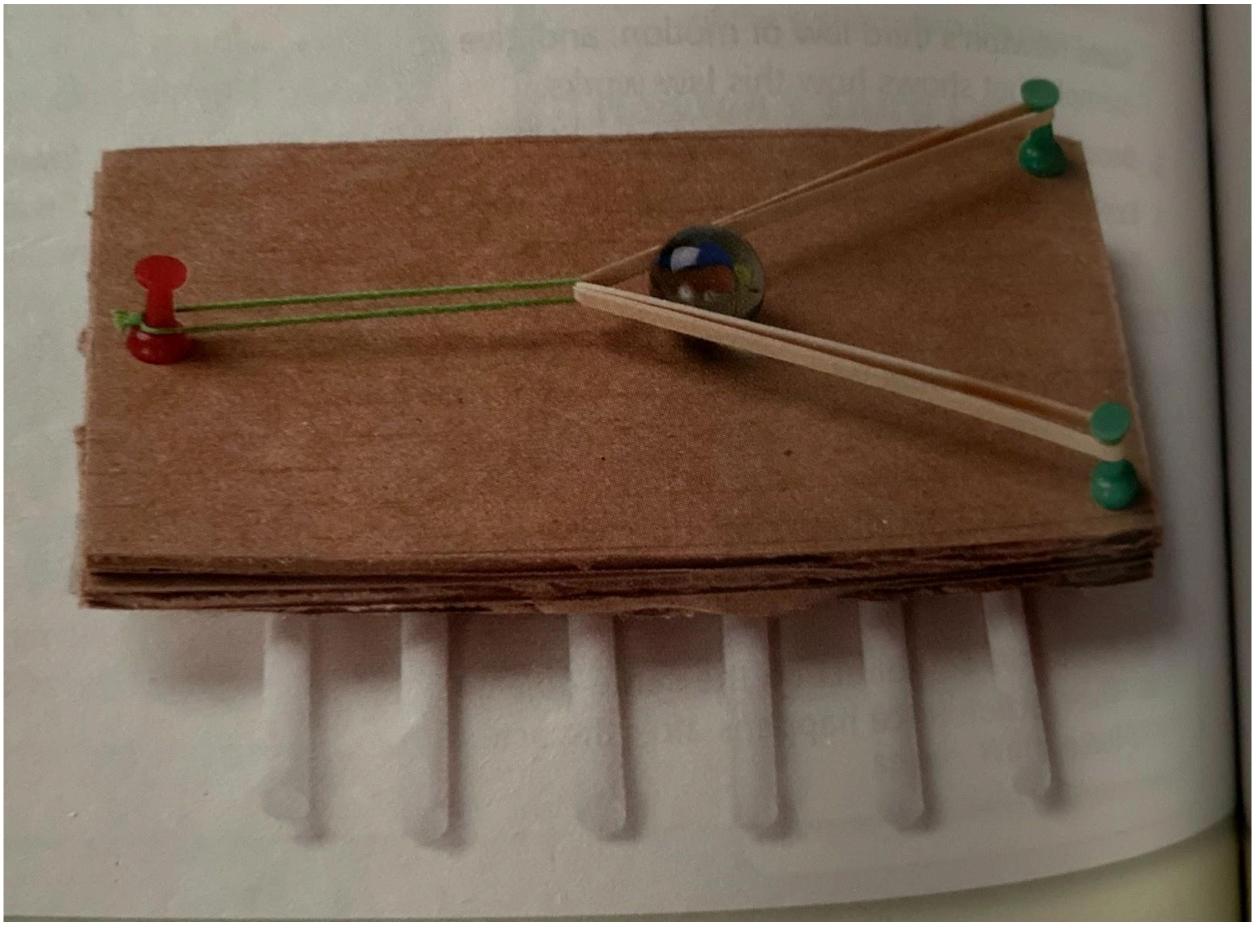
Questions

1. Which had more mass, the marble or the slingshot?
   Answers will vary based on the type of marble and cardboard used, but the slingshot will likely have more mass.

2. What happened to the slingshot when the marble was launched?
   The slingshot moved backward about 4.5 in.

3. Compare the movement of the marble to the movement of the slingshot. Was your hypothesis correct?
   Answers will vary. In our sample data, the marble flew forward 110.5 in. The slingshot moved backward, in the opposite direction, but not as far (only 4.5 in) because it had more mass. Yes, my hypothesis was correct.

4. Use Newton's third law to explain why the marble and slingshot moved the way they did.
   The slingshot exerted a force on the marble that made it move forward. The marble exerted an equal and opposite force on the slingshot, making it move backward.



Lesson 24: Investigating Human Work & Power

Data Table

Trial	Mass (kg)	Distance (m)	Time (s)	Force (N)	Work (J)	Power (W)
1	0.5 kg	0.75 m	25.5 s	5 N	3.75 J	0.15 W
2	0.5 kg	0.75 m	22.8 s	5 N	3.75 J	0.16 W
3	0.5 kg	0.75 m	20.2 s	5 N	3.75 J	0.19 W

**Data is just an example and will vary based on size of the bottle, length of the rope, and time it takes for the student to lift the bottle.*

Questions

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

   $F_g = ?$ $m = 0.5\ kg$ $g = 10\ m/s^2$
   $F_g = mg$
   $F_g = 0.5\ kg \times 10\ m/s^2$ $F_g = 5\ N$

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

   $W = ?$ $F = 5\ N$ $d = 0.75\ m$
   $W = Fd$
   $W = 5\ N \times 0.75\ m$ $W = 3.75\ J$

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

   Trial 1:
   $P = ?$ $W = 3.75\ J$ $t = 25.5\ s$
   $P = W/t$
   $P = 3.75\ J/25.5\ s$ $P = 0.15\ W$

   Trial 2:

P = ? W = 3.75 J t = 22.8 s

P = W/t

P = 3.75 J/22.8 s P = 0.16 W

Trial 3:

P = ? W = 3.75 J t = 20.2 s

P = W/t

P = 3.75 J/20.2 s P = 0.19 W

4. Did the amount of work completed change with each trial? Why or why not?
   No, because the amount of force stayed the same since the bottle's weight was the same every time, and the distance traveled also remained the same.

5. Did the amount of power you used change with each trial? Why or why not?
   Yes, because it took me a different amount of time to lift the bottle for each trial, and the faster I lifted the bottle, the more power I used.

Lesson 25: Exploring Conduction

Hypothesis: I think a thin wire will conduct heat more quickly than a thick wire because it has fewer particles, so the energy will be able to reach all of the particles faster.

Data Table

	Wire Diameter	Time to Melt Wax
Wire 1	1.0 mm	39.2 s
Wire 2	2.0 mm	26.3 s
Wire 3	3.0 mm	21.6 s

*Data is just an example and will vary based on the material and diameter of the wire and the amount of wax on the wire.

Questions

1. Was your hypothesis correct? Why or why not?
   My hypothesis was not correct. I thought the thinnest wire would conduct heat the fastest, but it was the opposite. The thickest wire conducted heat more quickly than the thinner ones.

2. How does your understanding of conduction explain the results you observed in the experiment?
   Heat energy is transferred through the collision of particles during conduction. Since thicker wires have more collisions happening throughout the same length, the energy can travel more quickly from one part of the wire to another.

Lesson 26: Simple Machines Challenge: Rescuing the Circus Elephant

Results for this activity will vary greatly. As long as the design follows the constraints in #3 of the instructions, the sky's the limit!

Lesson 28: Hands-On Wave Dynamics with a Slinky

Data Table

	Amplitude	Wavelength	Frequency
Wave 1	10 cm	100 cm	0.5 waves/s
Wave 2	25 cm	75 cm	3.4 waves/s

* Data will vary greatly depending on energy and speed used to make waves.

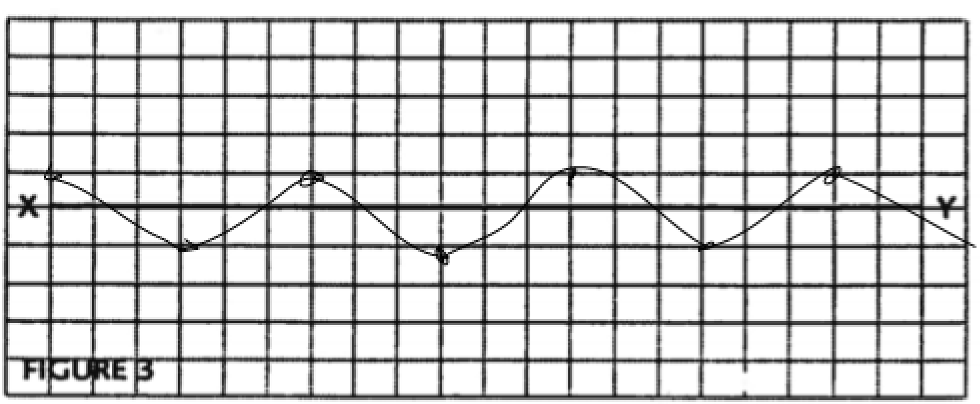
Questions

1. Compare the energy of waves 1 and 2. Which had more energy? Explain how you determined this.
   Wave 2 had more energy because it had a higher amplitude.

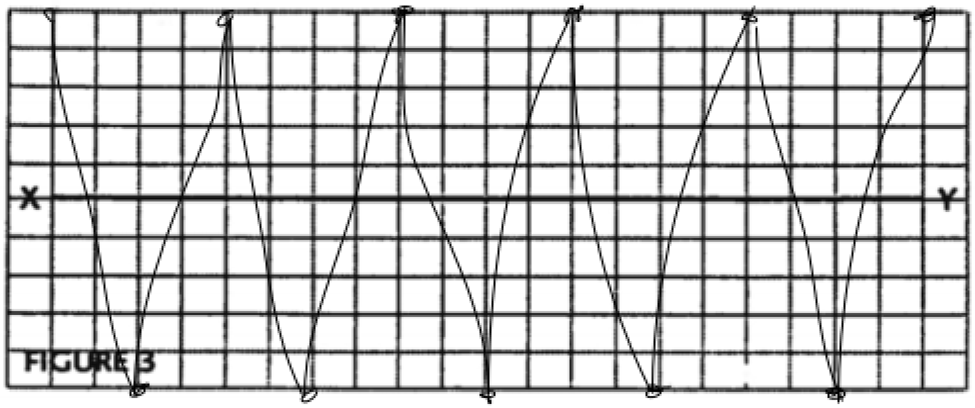
2. Is it possible to create a wave with a high frequency but low amplitude? If so, how would you achieve this? If not, why is it not possible?
   Yes, I could move the Slinky quickly, but not very hard so it would have a short wavelength but wouldn't go very high.

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.
   Yes, I could move the Slinky slowly, but with more energy so it went higher but would have a longer wavelength.

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.



Lesson 29: Frequencies of Sound

Playing the Ruler

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? Higher
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? Lower

Playing the Rubber Band

6. Stretch the rubber band tighter by moving your finger and thumb farther apart, then pluck it again. Is the note higher or lower? Higher
7. Stretch the rubber band even tighter and pluck it again. Is the note higher or lower? Higher
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? Lower
9. Stretch the rubber band tighter and pluck it again. Is the note higher or lower? Higher

Playing the Bottle

10. Fill the bottle halfway with water and blow across the mouth of the bottle again. Is the note higher or lower? Higher
11. Fill the bottle ¾ of the way with water and blow across the mouth of the bottle again. Is the note higher or lower? Higher

Questions

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

2. What type of musical instrument might the rubber bands represent? What factor did you change to influence the frequency/pitch?
   Stringed/guitar, violin, etc.; the tension

3. What type of musical instrument might the bottle represent? What factor did you change to influence the frequency/pitch?
   Woodwind/flute; the mass, amount of water, space for air particles to vibrate (this answer may vary, but any of the above are acceptable).

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?
   I would tell them to tighten/stretch the guitar string more to make the string vibrate faster, which would increase the pitch (a thinner string would also make the pitch higher).

Lesson 30: Light & Color Dynamics

Data Table

	Red & blue	Red & green	Blue & green	Red, green, & blue
Both lights 15 cm from wall	Magenta or Fuchsia	Yellow	Cyan or Aqua	White
One light 15 cm and one 30 cm from wall	If blue is dimmed, we see rose color. If red is dimmed, we see violet.	If green is dimmed, we see orange. If red is dimmed, we see chartreuse.	If green is dimmed, we see bright cyan or azure. If blue is dimmed, we see spring green.	

Questions

1. Did the observed results match your hypothesis?
   Answers will vary depending on the student's hypothesis.

2. How did varying the intensity of the lights (by changing the distance) affect the observed colors?
   When varying the intensity of the lights by changing the distance from the white surface, the observed colors can change in both the hue and the saturation of the color. Closer lights result in more intense and vibrant colors, while lights at greater distances produce dimmer and more subdued colors.

Lesson 31: Bending Light: Reflection & Refraction Diagrams

Data Table 1: Reflected Rays

	Angle of Incidence	Angle of Reflection
Trial 1	25°	26°
Trial 2	50°	53°

Your student's data will vary however the measured angle of incidence and angle of reflection should be identical or nearly identical if the lab was completed correctly.

Data Table 2: Refracted Rays

	Angle of Incidence	Angle of Refraction
Trial 1	28°	23°
Trial 2	47°	30°

Your student's data will vary, however the angle of incidence and angle of refraction will be different if the lab was completed correctly.

Questions:

1. What is the law of reflection? How did your results support this law?
   The law of reflection states that the angle of incidence is equal to the angle of reflection. In the lab, measurements of the angles of incidence and reflection showed that they were equal, confirming this law.

2. How did the angle of incidence affect the angle of refraction in your experiments?
   As the angle of incidence increased, the angle of refraction also increased, meaning that the light bent more as it entered the refraction block. This observation shows that the greater the angle at which the light strikes the

surface of the block, the more pronounced the bending of the light ray becomes.

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?
   If the material of the refraction block had a higher density, the light would bend more towards the normal line as it enters the material, resulting in a smaller angle of refraction compared to the angle of incidence. This means the light would change direction more sharply.

Lesson 32: Conductivity in Action

Data Table

Material	**Hypothesis** Good conductor? Yes or No	**Test** Conductor? Yes or No
Glass stirring rod	No	No
Metal nail	Yes	Yes
Aluminum foil	Yes	Yes
Wooden skewer	No	No
Copper wire	Yes	Yes
Piece of chalk	No	No
Plastic spoon	No	No
Cardboard strip	No	No

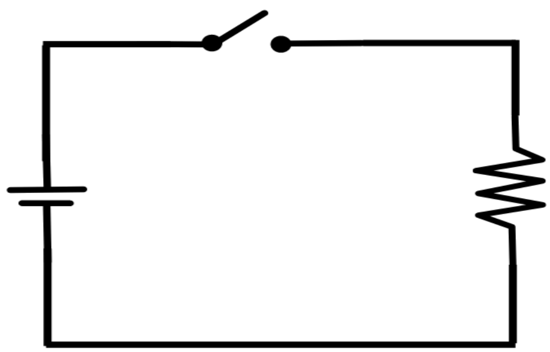
Questions

1. Were your hypotheses correct? Why or why not?
   Students should reflect on their predictions and analyze why some materials conducted electricity while others did not including specific examples from their data.

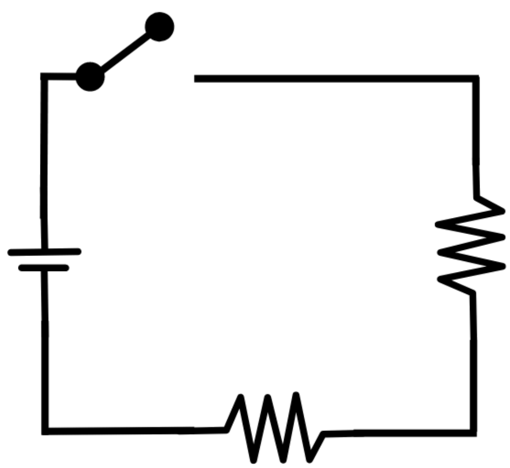
2. What are some other materials in your house you could test using this conductivity tester? Do you think they would conduct electricity? Why or why not?
   Answers will vary, but any answer with an explanation is acceptable.

Lesson 33: Circuit Discovery: Building & Understanding Connections

Circuit Diagram
Circuit With One Light Bulb

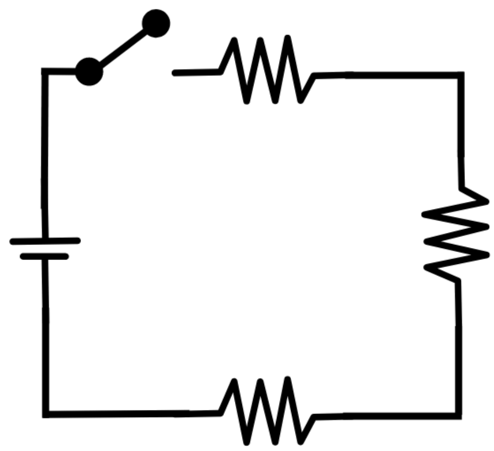


Circuit Diagram
Series Circuit With Two Light Bulbs



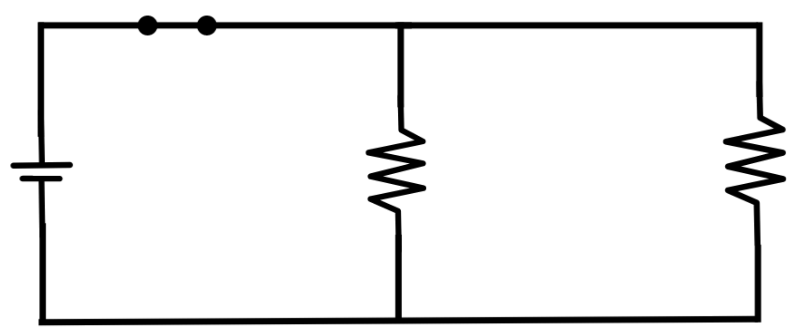
Circuit Diagram

Series Circuit With Three Light Bulbs



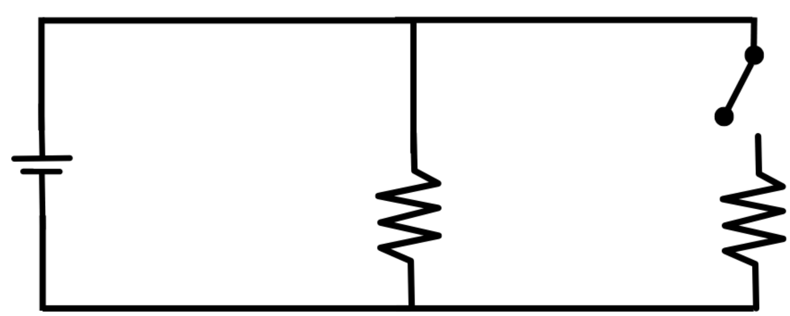
Circuit Diagram

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



Circuit Diagram

Parallel Circuit 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?
   The lights got dimmer as more light bulbs were added, because the same voltage from the battery was divided across all of the bulbs.

2. What happened when you added more light bulbs to the parallel circuit? Why do you think that is?
   The lights stayed the same as more light bulbs were added. Since each light bulb has its own circuit, it works independently of any other bulbs attached.

3. Can you explain how the switch controls the flow of electricity in your circuit?
   The switch acts as a gate for the electrical current. When the switch is closed, it completes the circuit, allowing current to flow. When it's open, it breaks the circuit, stopping the flow of electricity.

Lesson 34: The Science of Compass-Making

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?
   Students' magnets will each pick up a different number of paper clips depending on the strength of the magnet. Stronger magnets can attract more paper clips because they generate a greater magnetic force, while weaker magnets can pick up fewer paper clips.

2. What happened when you removed the top paperclip from the magnet?
   All of the other paper clips fell off of the chain.

3. What happened when you put the needle on top of the cork?
   The cork spun so that the needle was facing North.

4. What happened when you turned in different directions?
   The needle continued to point North.

5. Why does the needle point in a specific direction when you turn the bowl?
   The needle aligns itself with the earth's magnetic field, which has a north and south pole, causing it to point toward magnetic north.